Journal of Rehabilitation Research and Development

Rehabilitation R & D Progress Reports 1987

VI. Independent Living for the Disabled

A. General

B. Robotics

C. Communication Methods and Systems

D. Private / Public Programs

VI. Independent Living for the Disabled

A. General

Design of a New Toilet: Transfer and Access Pilot Study

Pascal M. Malassigne, M.I.D.
Veterans Administration Medical Center, Decatur, GA 30033

Sponsor: *VA Rehabilitation Research and Development Service (Pilot Proposal E951-PA)*

Purpose—This pilot study is aimed at collecting data on the ease of approach, access, and transfer to and from a wheelchair to a toilet. In addition, this project will study body position and reaching abilities of various user groups. This data is necessary for the preparation of a regular proposal for the design of an accessible toilet for people capable of independent transfer.

Design of Showers and Bathing Fixtures for Disabled and Elderly Veterans

Pascal M. Malassigne, M.I.D. and James A. Bostrom, M. Arch.
Veterans Administration Medical Center, Decatur, GA 30033

Sponsor: *VA Rehabilitation Research and Development Service*

Purpose—Bathing continues to be one of the most significant problems experienced by many disabled people. Most existing specialized bathing fixtures and adaptive devices for use with standard fixtures are unable to meet user needs or preferences because they are often expensive, not designed for residential use, unnecessarily complicated or difficult to maintain, or so specialized that the fixture can only be used by a disabled person and not the family.

New shower and bathing fixtures have been designed to solve many of the problems with existing fixtures. Each has been developed for use by disabled and older people in residential and institutional settings. Some of the fixtures can adapt existing bathing fixtures to make them more usable and other fixtures can be installed in new construction or in renovation work. Each of the designs has been developed to be mass-produced to limit the final cost of the fixture.

Progress—Five full-size bathing and shower fixtures have been developed from working prototypes which were evaluated during 1984-1986 (see *Rehab R&D Reports* 1986). The fixtures are:

1) Two models of a fiberglass roll-in shower, one designed as a 2-piece unit (with walls) for independent use and the other designed as a 1-piece base unit for use with an attendant.

2) A full-length cushioned bathtub insert with a soft surface that fits over a standard tub to provide a raised, contoured bathing surface.

3) A partial bathtub insert made of fiberglass that clamps to a standard bathtub to provide a contoured seat surface for showering while seated.

4) A removable cushioned seat with support frame to be installed in bathtub showers.

5) A wall-mounted fiberglass seat for stall showers with a contoured seat surface.

Results—Findings from the prototype evaluations of the roll-in showers and shower seats conducted from 1984 through 1986 showed that modifications were necessary. Most changes were made to refine the shape of the seat area to improve comfort, to increase drainage in the shower seats, or to increase the size of the fixture for the roll-in showers.

Evaluation of the cushioned bathtub shower, however, showed the need for a redesign of the fixture.

To better accommodate user needs, two new fixtures, a full-length and a smaller bathtub insert, have been developed to replace the previous design. The full-length insert is a cushioned fixture made of Ensolite (closed cell urethane foam with a vinyl skin) and reinforced from behind with fiberglass. This cushioned surface limits slippage during bathing, provides greater comfort, and reduces the potential for bruising the skin.

An evaluation protocol was developed and submitted to the VA Rehabilitation R&D Evaluation Unit requesting that an independent evaluation of the prototypes be conducted prior to commercialization. The request has been approved, and plans are being made for 70 fixtures to be distributed to five selected test sites for evaluation. Fixtures will be installed at each site and then used by disabled and older subjects for bathing for a 3- to 6-month period. Evaluations should begin in early 1988 and end in mid-year. Evaluation of the test data should be completed in late summer 1988.

Future Plans—The investigators are developing application packages which will describe each of the fixtures, their use, and installation. These packages will be used during the field evaluations and will be available to manufacturers who are interested in marketing the fixtures.

Handbike, an Arm-Powered Bicycle

Douglas Schwandt, M.S.; Larry Leifer, Ph.D.; Peter Axelson, M.S.
Rehabilitation Research and Development Center, Veterans Administration Medical Center, Palo Alto, CA 94304

Sponsors: *VA Rehabilitation Research and Development Service; Telephone Pioneers of America; British Columbia Program for the International Year of the Disabled Person through the University of British Columbia Athletic Department; Stanford Mechanical Engineering Design Division and Stanford Center for Design Research*

Purpose—The development, evaluation and subsequent availability of an arm-powered bicycle for individuals with lower limb disability will provide many benefits including fitness, therapy, mobility, integrated recreation and sport.

Progress—Six preproduction prototypes of the handbike arm-powered bicycle are now complete and ready for evaluation under the auspices of the VA Rehabilitation R&D Evaluation Unit. The Handbike rider both powers and steers the front wheel through arm-cranks which essentially replace handlebars found on a standard bicycle. Backpedaling actuates a caliper brake. The rider sits with his or her legs to either side of a crank tower, which may be lowered on to the leg rest for easy transfer to and from a wheelchair. Side casters provide support at an adjustable bike lean angle (10, 15, or 20 degrees). The side casters may also be fastened down to create four-wheel stability for going up ramps and indoors.

Results—With the evaluation soon to begin, results will be reported in the next issue. However, informal results of test riding have been very encouraging, and a few individuals have bought Handbikes through custom bicycle builders.

Future Plans—In addition to final documentation, the current work focuses on the writing of a product manual with information about learning to ride the Handbike, and how to take care of it.

Publications and Awards Resulting from This Research

Design Development of Arm-Powered Bicycles for the Disabled. Schwandt DF, *SAE International Congress*, SAE Paper 840023, 1984.

Para-Bike: An Arm-Powered Bicycle. Schwandt DF, *RESNA 6th Annual Conference*, 3:378-380, 1983.

Federal Design Achievement Award

The Use of Capuchin Monkeys as Aides for Quadriplegics

Mary Joan Willard, Ed.D.
Boston University School of Medicine, Boston, MA 02135

Sponsor: *VA Rehabilitation Research and Development Service*

Progress—During the past 3 years of this project, research and development efforts have focused on the refinement and standardization of procedures by which simian aides are produced. Over the past year, a training manual and series of training videotapes were completed, allowing for replication of training results.

With the use of these training materials and supervision from an experienced trainer, college work/study students have been successful in training a basic repertoire of tasks in approximately one and one-half times the amount of time it takes an experienced trainer to achieve the same results. Via a subsidized college work/study program, college students can be hired at about 15 percent of what it would cost to hire a full time experienced trainer. Students are limited to a 20-hour work week but they can make a two- to four-year commitment to the program.

Results—Placement evaluations indicate that problems which arise tend to be in the areas of: 1) the breakdown of equipment (primarily the monkey harness which holds a shock/tone unit in place, or the laser pointer); and, 2) the quadriplegic owner's lack of understanding of basic behavioral processes. The most common example is when the owner inadvertently rewards the monkey for engaging in undesirable behavior. A primary source of satisfaction is the durability of the monkey's learned behavior. Several owners who have spent weeks confined to their bed or hospital room report that their monkey retains mastery of tasks with little or no review. The continuing pleasure and stimulation derived from monkey/owner and monkey/visitor interactions also have contributed to owner satisfaction.

Future Plans—During the coming year, development efforts will focus on the following: 1) refining the procedures used during a placement, including the preparation of instructional video material to train the quadriplegic, his family, and aides, in proper care and management of the monkey; and, 2) further refinement of monkey-related equipment as well as duplication of every piece of equipment likely to break down. Feedback will be obtained on the success or failure of these efforts from 6 new placements scheduled over the course of the next 12 months.

Supported Employment for Youth with Learning Disabilities

David Gilmartin and Marcia Ortiz
Supported Work Employment Project (SWEP), The Center for Independent Living, Berkeley, CA 94704

Sponsor: *The Center for Independent Living, Inc.*

Purpose—The Supportive Work Employment Project (SWEP) is an OSERS grant funded program whose main goal is to provide severely learning disabled and multiply-disabled youth (ages 16-22) with vocational counseling, independent living skills training, job preparation, job placement, and supported work, in order to assist them in their transition from school to work.

The main goals of the project are to: 1) provide services to 30 learning disabled youth in the areas of prevocational counseling, assessment, occupational exploration, job readiness, job skills, job placement, supportive work and on-the-job training; 2) provide supplementary services which will enhance employability, such as independent living skills training, including attitude development, interpersonal skills, and goal-setting skills; 3) familiarize and facilitate clients' use of services at CIL and other appropriate social service agencies in the area; and, 4) provide technical assistance to employers to facilitate the successful placement and maintenance in employment of clients in jobs.

Progress—The Supported Work Employment Proj-

ect is an action program, applying group work, peer counseling, vocational counseling, and supported employment principles in work with learning disabled youth. The program is taking place primarily with students of Berkeley High School, Berkeley, CA, and Oakland Technical High School, Oakland, CA. A Job Club format is used for teaching the essentials of job readiness, applying for jobs, and interviewing. These groups meet weekly.

Counseling with participants, and with their families, is a major support service. Participants also are provided support for remembering appointments and interviews, with transportation, and with morale and attitude help for approaching interviews.

Preliminary Results—Out of 42 youth enrolled, 31 remained active in the program; 25 have been placed in employment or in higher education during the life of the grant.

Future Plans/Implications—In California, state-supported funding of supported employment exists for persons with developmental disabilties, and is being developed at present for those with mental disabilities. These two disability groups are the first to be served in supported employment because state funds exist to provide services for them, and only a rechanneling has been or will be necessary. Supported employment services for persons with severe physical, sensory, or other types of disabilities are developing more slowly because new sources of funding must be identified and secured.

At the time this is being written, funds to continue the program have not been received. The author believes regular funding for supported employment for persons with learning disabilities (in California) is 2 years away from being achieved.

We believe we have seen greater difficulty in working with older learning-disabled youth than with the younger ones. The difficulty seems related to a compound of low self esteem, low motivation, more failure experiences, defensiveness about having a disability, and more habituated ways of appearing normal while coping with a disability. The implication is that for supported employment to have maximum benefit with youth, it must be defined and programmed in ways which allow work with in-school youth, reaching even younger children than the present program has attempted.

Promoting Rehabilitation Services and Policies: Worksite-Based Employee Assistance Programs (EAPs) as Effective Advocates

Sheila Akabas; Marian Krauskopf; Ellen Brickman
Columbia University School of Social Work, New York, NY 10025

Sponsor: *The Center for Social Policy and Practice in the Workplace*

Purpose—This 3-year project will evaluate current Employee Assistance Program (EAP) practice in relation to disability management in worksettings, identify model programs in worksettings, and design new programs that will demonstrate a range of possible interventions. Finally, in the last year, conferences will be held that will present the findings of these demonstrations to an audience that may include other interested worksettings, providers of services, insurance companies, private councils, and other groups interested in worksite-based disability programs.

Progress—A mail survey of over 1000 EAPs was accomplished in the first year with over 200 sites returning the questionnaire. An analysis of this data will appear in a survey report which will be available by the end of September 1987. In addition, five sites in New York, Connecticut, and Massachusetts have developed demonstration programs, each one examining a different approach to disability management. A sixth site, a consulting company specializing in Workers Compensation is also developing a presentation to describe their own experience with EAPs in the management of Workers Compensation cases. In April and May, 1988, three conferences are being planned, one each in Boston, New York, and Washington. These conferences, sponsored jointly by The Workplace Center and The Institute for Rehabilitation and Disability Management of The Washington Business Group on Health, will examine practical approaches to worksite disability management

generally and emotional disability in particular, as well as new research which relates to this issue. The demonstration sites will participate in presenting their experiences.

Results—Survey: Respondents represented a wide range of worksettings and 33 states. Almost one-third had 1500 or fewer employees; one-third between 1600-4000, and 20 percent had between 4000-10000 employees. The data developed a profile of the EAPs themselves. Some of the findings specific to disability management are: 1) Although most EAPs were established within the last five years, the older the EAP, the more likely they were to identify disability management as one of their activities. Another related finding is that the older the EAP, the larger the staff size. These EAPs may have the staff capacity to handle a broad rather than a single purpose assignment. 2) Organizational structure appears to influence the degree of EA involvement in disability management: 77 percent of EAPs housed in medical or 73 percent reported to the CEO said they were active in disability management as against 52 percent reporting to Human Resources/ Personnel. 3) Over one-half the EAPs did collaborate with many departments that work with disability, including Medical Health Promotion and Disability. EAPs are in a good position to help coordinate worksite approaches to disability management. 4) Although 55 percent of EAPs said they were active in disability management, it is clear that the bulk of these focused primarily on emotional disabilities. Only 5 percent of the EAP population presents with a physical disability as the major problem.

Demonstration programs are experimenting with new outreach mechanisms to identify employees and designing supervisory training to encourage early referral and the use of the EAPs in assisting in making the referral. They are also coordinating the EAP and its case management capacity with an existing workers compensation program and describing a financial mechanism for supporting light duty work.

Research Into Design Requirements for Access by Children With Physical Disabilities

John H. Bails, B.E., and Barry R. Seeger, Ph.D.
Rehabilitation Engineering Department, Regency Park Centre for Young Disabled, Kilkenny, S.A. 5009 Australia

Sponsor: *Channel 10 Children's Medical Research Foundation of S.A.*

Purpose—There are currently no adequate Australian or international design rules for access by children with physical disabilities. This research is intended to lay the foundation of the development of design rules for safe and convenient access by physically disabled children.

Progress—Test equipment has been designed and built, and now occupies a testing laboratory of 100 square meters. The 30 test stations include variable rise steps, variable tread lengths, a range of ramps and curb ramps, measurement of reach, adjustable height basin, adjustable height toilet pan, various handles, shelf heights and door opening force.

Future Plans—In the latter half of 1987 it is intended to conduct tests on at least 250 young people aged 5-18 who have a physical disability, and who use a range of walking aids and wheeled mobility aids.

Development of a Trailable Ablution Unit Able to be Handled and Used by a Wheelchair User

John H. Bails, B.E., and Barry R. Seeger, Ph.D.
Rehabilitation Engineering Department, Regency Park Centre for Young Disabled, Kilkenny, S.A. 5009 Australia

Sponsor: *Channel 10 Children's Medical Research Foundation of S.A.*

Purpose—All trailable or relocatable toilet-type units so far produced in Australia and overseas for use of disabled persons have fallen short of the real needs of disabled persons who want a unit they can

handle and use themselves and that will not involve a lot of setup problems and expenditure.

The aim of this project is to produce an ablution unit that can be carried to and on sites and used by disabled persons, including a person in a wheelchair, so that such persons are able, independently, to travel to unserviced beaches, parks and remote camping areas and enjoy life away from the built environment. No unit presently exists that will allow the independence that will be provided by the proposed ablution unit.

Enhanced Understanding of the Economics of Disability

Dale Hanks; Monroe Berkowitz; Stanley E. Portny; David Dean
State Department of Rehabilitative Services, Richmond, VA 23230

Sponsor: *Commonwealth of Virginia, Department of Rehabilitative Services; National Institute on Disability and Rehabilitation Research*

Purpose—The objective of the project is to enhance the understanding of the economics of disability for the further improvement of public policies and programs related to disability. The project seeks to estimate the costs of disability; study the relationship between program effectiveness and system and client variables; study the effect of program administrative and organizational structure on service effectiveness and on the disabled population; and provide information on organizational, programmatic, and funding alternatives for public policy decisions. The target group expected to benefit from this project includes federal and state legislators, federal and state administrators of programs related to disability, and ultimately all disabled people.

Progress—Our principal task is developing an econometric model of the vocational rehabilitation program. We are studying the relationships between client characteristics, services provided, and rehabilitation outcomes. The main idea of the model is to make explicit the relationships among these significant program elements. We are building a national database through the help of 60 counselors from the California Department of Rehabilitation, the Texas Rehabilitation Commission, and the Virginia Department of Rehabilitative Services. We expect to have extensive information on 1,500 rehabilitation clients in these three states. We have not yet completed our database, but we expect completion of data collection and analysis by the end of 1987. We are also gathering data to estimate the costs of disability in the United States in general.

We are now in the final year of a 5-year project, funded in part by the National Institute for Disability and Rehabilitation Research. Data collection continues in Virginia, Texas, and California, and some preliminary analysis has been done. A final report is scheduled for publication in May, 1988.

Results—Expected results include: 1) improved methodologies for estimating the costs of disability; 2) updated national estimates on the costs of disability; 3) conceptual models to represent the relationships among rehabilitation programs, clients, and environmental variables; and, 4) current trends in the federal and state organizational structure of disability programs.

Future Plans/Implications—This project responds to a national need for a better understanding of the economics of disability. It is designed to enable public policy-makers to make more informed decisions about the optimal allocation of funds among public programs that serve disabled people.

Workstation Development for the Mobility Impaired

A.J.Bradshaw; Thomas Single; Michael Burrow
Center for Rehabilitation Technology, College of Architecture, Georgia Institute of Technology, Atlanta, GA 30332

Sponsor: *Division of Rehabilitation Services, Georgia Department of Human Resources and Center for Rehabilitation Technology, Georgia Tech*

Purpose—The Center for Rehabilitation Technology (CRT) at Georgia Tech is in the fourth year of an ongoing program to develop a modular, interchangeable system of workstation components for mobility-impaired individuals. The goal of the program is to develop a system of components configured and arranged to optimize the individuals's remaining mobility, strength, and dexterity in the vocational or educational setting.

In general, as a patient's mobility decreases, the need for automated assistance to complete a given task increases and is accompanied by the high cost of automation. However, the modularity of the CRT system allows custom configurations, with common components, resulting in a prescriptive device with cost-effective production.

The CRT workstation designs respond to four degrees of mobility impairment: Level 1—Poor to fair finger and hand dexterity, with the ability to use keyboard with hands and to pick and place paper and/or files by hand. No automated modules or computer control required. Level 2—Poor finger and hand dexterity and upper body strength. Has ability to slide materials about work surface. Usually restricted to powered wheelchair. Automated modules required for positioning. Level 3—No movement of upper extremities, but with some control of neck muscles. Has ability to use mouthstick. Automated modules required for material handling with robotic manipulation. Level 4—No movement of upper extremities, including neck. Mouthstick of little use. Ventilatory support usually required. Confined to bed or powered wheelchair. Sophisticated computer system usually needed for employment. Esoteric computer access usually required.

Progress—During the past year, CRT designed and implemented the Level 3 office environment workstation for a C3 quadriplegic. The computer-controlled robotic workstation has been installed and is currently being used and evaluated.

The workstation consists of two carousels, one of which contains the user's files and another which contains three work platforms tilted at a 60 degree angle. A book elevator containing six sliding drawers holds the user's books and notebooks.

A robot arm has also been developed to be integrated into the workstation. The purpose of the robot arm is to "fetch" files and place them on one of the three work carousels in front of the user. The arm will also pull out a specified drawer of the book elevator, giving the user access to the desired book or notebook at the proper reading and mouthstick manipulation angle.

Numerous technical and human factors issues were considered and resolved in developing the workstation. Some factors which had to be considered included the interface between the computer and user, cost of the system, safety considerations for the user, ease of installation, and ease of use. The system has been developed such that it may be tailored to an individual user. All components are modular units which can be added or removed, based on the user's preference.

Developing a suitable interface between the user and the computer-controlled workstation was a major objective of the project. Because the system had to be user friendly, it was designed to minimize the number of keystrokes required, and the software was modified to accommodate the use of a mouthstick for entering data from the computer keyboard. The importance of this is especially evident when a quadriplegic needs to use word processing software; it is not possible for him to hold down one key (the shift key, for example) and strike another key at the same time.

Safety was a major concern in the development of the workstation. No exposed moving parts or protruding objects which could endanger a quadriplegic were used. In addition, the design of the robot arm avoids situations which could potentially be harmful if the arm were to fail.

The overall configuration of the workstation makes it an attractive and useful aid for many quadriplegics. The design has been carefully thought out in an attempt to accommodate as many needs of a typical

user as possible. The main objective in the development has been to make the system helpful, attractive, and easy to use.

Preliminary Results—Evaluation observations indicate that the client's independence and productivity have increased. As he becomes better accustomed to the electronic data handling by computer and hard copy manipulation by the robot, we predict his productivity will increase dramatically. Evaluation and refinement will continue through June of 1988.

Construction of a Home Unit for Live-In Trialing of Assistive Devices

Gary L. Wilson, B.Soc.Admin., and Barry R. Seeger, Ph.D.
Regency Park Centre for Young Disabled, Kilkenny, S.A. 5009 Australia

Sponsor: *Housing Trust of S.A.*

Purpose—This High Technology Unit will give disabled people the opportunity to live with various kinds of technology and the latest assistive devices, in an optimal setting. Through one or two week live-in periods, even families can try and test the equipment most appropriate to meet their individual needs.

Progress—Construction began November 19, 1987, for completion in early 1988. Building plans for the structure used standard Housing Trust plans of a unit, modified for people with disabilities. Interior, bathroom, and kitchen details will be designed in conjunction with occupational therapists. The client group is being accurately targeted, and a coordination mechanism for the various agency users is being developed. The list of possible equipment items is being finalized with loan/sponsorship issues to be settled. Users will need a scheme to supply assistive devices and modification in their own homes after testing them at the High Technology Unit.

Documenting and Utilizing Programs that Provide Community Adjustment and Independent Living Services for Persons with Spinal Cord Injury

Margaret A. Nosek, Ph.D.
Baylor College of Medicine and The Institute for Rehabilitation and Research, Houston, TX 77030

Sponsor: *National Institute on Disability and Rehabilitation Research*

Purpose—The purpose of this project is to collect and maintain information about independent living and community adjustment programs that serve spinal cord injured people; to provide an effective means of communicating new ideas and experiences among individuals operating these programs; and to provide access to a dependable source of technical assistance related to these programs.

Progress—Nonexperimental survey methodology is being used. The data from earlier administrations of this survey were summarized in frequencies according to specified categories of interest, and some correlation studies were done to determine trends in independent living program development. Data from project surveys were used to assess the types of services being provided for persons with spinal cord injury, and the source and amount of funds being used. The survey instrument has been revised, expanded, pilot-tested, and readministered to all identified independent living programs. Data are being analyzed using univariate and multivariate techniques and will be compared to earlier findings.

In order to facilitate use of the information that is developed, the project maintains a computerized bulletin board, a telephone communication network with all the extant independent living programs, and a mailing list of approximately 2000 additional individuals and organizations. Knowledge transfer strategies depend on the specific topic or set of information, but they usually involve extensive reviews of existing literature, interviews with inde-

pendent living program administrators, staff members, and consumers, and supplementary reviews by additional experts both in and out of the independent living field.

Preliminary Results—The 1986 administration of the survey yielded a 70 percent response rate (166 programs), with 51 percent (54 programs) providing complete data. All data have been entered into the ILRU National Database on Independent Living Programs. Extensive analysis is being conducted to examine a broad array of variables related to the delivery of independent living services to persons with spinal cord injury. Preliminary results indicate that persons with spinal cord injury are served by 80 percent of independent living programs, an increase of 1 percent from 1984. Of programs meeting the criteria for independent living centers, 95 percent report serving this population. Further investigation into the significance of the "center" model is being conducted.

In addition to data runs and reports in response to specific inquiries, there have been many products from this study to date. Two major presentations and two poster sessions on the preliminary results have been given at four national conferences to date. The Directory of Independent Living Programs has been updated and reissued five times in the past year. The new Registry of Independent Living Programs has been completed.

Future Plans/Implications—By the end of the year, a third major publication will be completed, analyzing the longitudinal database in relation to services to persons with spinal cord injuries and discussing policy implications of the findings. The ILRU project is continuing its training, networking, and information dissemination activities in the area of independent living and maintains an ongoing effort to update its databases.

An Operational Definition of Independence

Margaret A. Nosek, Ph.D.
Baylor College of Medicine and ILRU Research and Training Center on Independent Living at TIRR, Houston, TX 77030

Sponsor: *National Institute on Disability and Rehabilitation Research*

Purpose—This project is designed to develop an operational definition of independence that spans four uses of the term: in a behavioral sense, as a psychological trait, in connection with functional abilities, and with respect to individual social performance. The objective is to develop an assessment battery to quantify an individual's independence in each of the above specified domains.

Progress—A thorough literature search, analysis of assessment instruments related to the many components of independence, and consultation with national leaders in the independent living movement led staff to decide that the primary components of independence are feelings of control, psychological self-reliance, and behavioral self-reliance. Characteristics of social independence, as originally proposed, were determined to either be subsumed under behavioral self-reliance or more accurately regarded as correlates of independence. A concept paper was developed on these conclusions and submitted to five senior project consultants for comment.

Three assessment instruments were identified from the literature to operationalize each of these factors, forming the Personal Independence Profile (PIP). Flanagan's (1973) list of life domains was modified and developed into two sets of questions with Likert-type responses, one to measure feelings of control in each life area and the other to measure the importance of each area to one's life in general. The 48 items of Fordyce's (1953) Dependence/Independence Scale which relate to feelings were chosen to measure psychological self-reliance. The Arthritis Impact Measurement Scale (AIMS) by Meenan et al. (1980, 1982) was selected as the measure of behavioral self-reliance, in large part because it covered social as well as physical functioning. A comprehensive demographic questionnaire used in a previous study will accompany the PIP to measure other personal and social variables, such as living arrangements, educational and employment status, income, health, and use of assistive devices.

Preliminary Results—The PIP has been pilot-tested

on 10 subjects identified through the Houston Center for Independent Living. A coding and data entry system has been established and implemented, and approaches to analysis have been trial tested. The Houston Center and three other centers for independent living have agreed to assist in identifying subjects and mailing out questionnaires.

Future Plans/Implications—Full testing of the PIP and the accompanying demographic questionnaire will be conducted in July. Analysis and reporting of results as proposed will be completed by the end of the grant year. Further refinement of the PIP and in-depth validity testing through two application studies are being proposed as new efforts for the next year.

Parameters of Independent Living Programs: A Longitudinal Study

Margaret A. Nosek, Ph.D.
Baylor College of Medicine and ILRU Research and Training Center on Independent Living at TIRR, Houston, TX 77030

Sponsor: *National Institute on Disability and Rehabilitation Research*

Purpose—This study builds on three previous comprehensive descriptive studies of independent living programs conducted by ILRU over the past ten years. (*See* "Documenting and Utilizing Programs that Provide Community Adjustment and Independent Living Services for Persons with Spinal Cord Injury," elsewhere in this issue.) The purpose is to maintain a database on the status of independent living programs nationally and, through analysis, identify trends in their development, the emergence of new problems and new solutions for the delivery of independent living services, and changes in the characteristics of consumers of these services.

Progress—The survey used in previous studies by ILRU has been revised and refined using input received from senior project consultants. It has been pilot-tested and further refined, and administered to each of the more than 300 programs listed in the ILRU Directory of Independent Living Programs. Data has been gathered concerning populations served, services provided, characteristics of persons providing services, methods by which services are provided and programs administered, sources of funding, and relationships between programs and their community. These data have been coded and entered into the computer for univariate and multivariate analyses, thus establishing the ILRU National Database on Independent Living Programs.

Results—The project maintains a computerized bulletin board, a telephone communication network with all the extant independent living programs, and a mailing list of approximately 2000 additional individuals and organizations. Responses are given to individual inquiries using specific data runs and reports.

Future Plans/Implications—The ILRU Research and Training Center on Independent Living at TIRR is continuing its training, networking, and technical assistance activities using these data for the benefit of any independent living program or individual interested in independent living.

The Definition of "Peer": Consumer Perspectives and Significance in the Delivery of Counseling Services

Margaret A. Nosek, Ph.D.
Baylor College of Medicine and ILRU Research and Training Center on Independent Living at TIRR, Houston, TX 77030

Sponsor: *National Institute on Disability and Rehabilitation Research*

Purpose—This project is intended to provide initial data on the perceptions of disabled persons with respect to the definition of "peer" and the provision of counseling services by peers. The consumers'

opinions will be solicited on which characteristics of peer counselors enhance credibility and lead to the highest levels of satisfaction from peer counseling services delivered by independent living centers.

Progress—Analysis of the literature search and further probing of Berkeley Planning Associates' data from the national evaluation study, has yielded several persistent questions related to peer counseling. Most available information concerns outcomes from peer counseling services and debates over appropriate techniques for delivery of these services. A question that surfaced is how consumers perceive the services; specifically, how does the consumer rate the credibility of the counselor. A design for this study has been developed which examines the degree to which these perceptions are influenced by whether or not the counselor has a disability, the content of the interaction (disability related or not), and reputational cues given for the counselor (high or low). The dependent variable, consumer perception of counselor credibility, will be measured by the Counselor Effectiveness Rating Scale of Barak and LaCross (1975). A demographic questionnaire will be administered to all subjects after testing.

Materials for implementation of this design include photographs of the counselors, taped descriptions of the counselors' backgrounds, and the content of the interactions. Due to limited financial resources for material preparation, it was decided to examine only the perceptions of persons with physical disabilities for this study. The pilot test, refinement of materials, initiation of full testing, and dissemination of results will occur before the end of this project year.

Independent Living in Rural Areas: A Longitudinal Study

Margaret A. Nosek, Ph.D.
Baylor College of Medicine and ILRU Research and Training Center on Independent Living at TIRR, Houston, TX 77030

Sponsor: *National Institute on Disability and Rehabilitation Research*

Purpose—Under a 3-year grant from NIDRR, ILRU completed a project to expand independent living opportunities for disabled residents of rural areas. Six demonstration sites were established and given ongoing support until the project was completed in April of 1986. The current Research and Training Center project is designed to examine the long-term effects of these interventions in terms of quality and quantity of ongoing activities and outcomes for the community.

Progress—The first component of this evaluation project has involved an initial assessment of three demonstration sites at the time that ILRU funding through the rural demonstration grant was discontinued. This initial assessment allowed for the collection of baseline data for comparison purposes following assessments in subsequent years. The second component is follow-up interviews of selected individuals living in the demonstration site areas. The third component will involve two follow-up examinations of these demonstration sites at 18-month and 36-month intervals.

Preliminary Results—To date, three demonstration sites have been chosen from among those previously established by ILRU. Consultants at each site have conducted the Community Needs and Resource Survey developed by ILRU during its rural demonstration project, thus establishing baseline data. Background information on these communities has also been acquired. Staff have decided to expand the original plan for interviewing residents from these communities to include groups with various levels of involvement in projects supported through the ILRU Rural Demonstration Project, i.e., advocacy group leaders, advocacy group members, community leaders, and general public. Interview protocols and a plan for data gathering and analysis are being developed. This design will be implemented at the 18-month interval from the collection of baseline data, which was July of this year.

Future Plans/Implications—By the end of this year, two sites will be visited and surveyed. Fiscal restraints have necessitated postponement of surveying the third site until the beginning of year three.

Data will be coded and entered into the computer for later analysis. The survey will be repeated at the 36-month interval, after which comprehensive longitudinal analysis will be conducted.

Production and Satellite Broadcast of Self-help Videotapes for the Handicapped

Dr. Lois O. Schwab; Judi A. Hansen, M.A.; Janet M. Buskey, O.T.R.
University of Nebraska-Lincoln, College of Home Economics, Independent Living Rehabilitation Unit, Lincoln, NE 68583-0809

Sponsor: *National Institute on Disability and Rehabilitation Research*

Purpose—A new videotape series, entitled "An Orientation to Technology for the Physically Challenged," was available as of September 1, 1987. The three videotapes are new educational tools for use by professionals to assist physically challenged individuals and their significant others in becoming aware of a general sampling of low cost devices now available to enhance a disabled person's quality of life.

The videotape on "Communication," featuring Dr. David Beukelman, professor of Special Education and Communication Disorders, demonstrates the use of a variety of augmented communication techniques that may be useful depending on the severity of the individual's speech and writing disability, lifestyle, and residual capability to communicate. The "Upper Extremity" and "Lower Extremity" videotapes illustrate basic devices and techniques that help solve problems in daily living activities such as eating, dressing, cooking, and hygiene. Architectural adaptations of the environment are also demonstrated. The content sets a baseline of knowledge that all people dealing with disabilities should have. This video series will be of particular interest to rehabilitation agencies and services; independent living centers; critical care facilities; educators; physicians, nurses; patient care providers; universities and college departments: educational programs for physical therapists, occupational therapists, speech pathologists, nursing, and rehabilitation—introductory information for junior and senior students; care givers; patient and family education programs; newly disabled/physically challenged individuals and professionals not involved in rehabilitation. A brochure accompanies each tape, listing the devices in sequential numbering, the manufacturers and suppliers, company addresses and phone numbers, and resources to contact for further information. The three videotapes were developed at the University of Nebraska-Lincoln through the cooperative efforts of the independent living rehabilitation unit of the department of human development and the family, college of home economics; the media services division of the department of speech education and communication disorders, teachers college; and the media department of UNL academic telecommunication, division of continuing studies.

Progress—The satellite teleconference held May 13th, 1987 was broadcast internationally to 125 sites throughout the United States and Canada. The overall objective of the teleconference was to acquaint persons who work with the physically disabled and their families with a means of providing information about the use of low cost technology in various life functions to disabled individuals and their families. Participants evaluating the teleconference and the three videotapes, provided constructive criticism for future teleconferences and suggested revisions for the tapes.

Preliminary Results—Preliminary results of the pre- and post-evaluations indicate a most favorable response: 1) interest in utilizing the tapes in a magnitude of ways "As an instructional tool with patients, as an educational program for O.T.'s, P.T.'s, nurses, and as introductory information for students." 2) "All those who work with the handicapped should see it, along with the handicapped, themselves." 3) Requests for additional teleconferences and video series on related topics: case studies, devices for specific disabilities. The final report was completed in October 1987.

Development of Design Criteria and Performance Standards for Barrier-Free Environments

M.A. Wylde, Ph.D.; K.S. Bunch, Ph.D.; J.R. Zellner; A. Baron-Robbins; T. Festervand, Ph.D.
Advanced Living Systems Division, Oxford, MS 38655

Sponsor: *National Institute on Disability and Rehabilitation Research*

Purpose—The purpose of the project is to develop a comprehensive set of design criteria and performance standards for architectural designs and furnishings that will enable the severely disabled to function independently in private or public environments. To meet this primary goal, specific tasks will be accomplished for the following objectives: 1) Collect and analyze human factors data to delimit the spectrum of human abilities and to develop quantifiable descriptors of human performance relevant to the tasks of daily living activities; 2) Develop design criteria and performance standards for furnishings and architectural designs for barrier-free environments; 3) Ensure that the design criteria and performance standards are applicable to all housing and public-use building types are acceptable to the target groups of end-users (both able-bodied and disabled); builders, architects and developers; and professionals in related fields; 4) Determine the costs associated wth constructing barrier-free environments built according to the design criteria and performance standards and compare to a) the costs associated with constructing conventional housing and b) the costs of providing alternative housing options for disabled individuals.

Progress—Two data collection procedures will be used to gather new information. 1) The first will measure human factors for descriptive analysis. It will include two-dimensional measurement of human movement using a digital camera system. This human factors data together with data from a comprehensive search of the literature will be used to generate new design criteria and performance standards; and 2) The second collection of data will be an experimental study to test the new design criteria and performance standards. The data will be collected in two settings. The control environment will be constructed according to existing standards: a model apartment will be constructed according to design criteria and standards established as a product of the initial stage of this grant. Human subjects will perform designated daily living activities in both settings.

Future Plans/Implications—Based on the findings of the second data collection, experimental design criteria and standards will be revised. Applicability and acceptability for the new design criteria will be determined by a target group of end-users to include builders, architects, developers, and professionals. A culminating activity will be development of sample plans for public and residential buildings to include cost benefit analyses. Possible directions for the future are envisioned as the project progresses. At the conclusion of the project, more specific implications for future research will be indicated.

Computerized Task Guidance for Cognitively Impaired People

N.L. Kirsch, Ph.D.; S.P. Levine, Ph.D.; L.A. Jaros, B.S.
Rehabilitation Engineering Program, Department of Physical Medicine and Rehabilitation, University of Michigan Medical Center, Ann Arbor, MI 48109

Sponsor: *Robert Wood Johnson Foundation, Princeton, NJ*

Purpose—The general aim of this project is to test the hypothesis that a computerized task guidance system can be used to improve functional performance of complex tasks for individuals with moderate to severe neurocognitive deficits. This type of intervention, which we have termed a cognition orthosis, has the potential to facilitate user performance for a wide range of functional activities, dramatically increase independence, and ease the responsibility for costly care typically assumed by family members or community facilities.

Progress—Over the past four years, a computerized cognition orthosis system has been developed in our laboratory, in an attempt to meet the needs of brain-injured individuals who no longer respond to restorative therapies and need compensatory intervention to perform functional tasks. This system is used to develop "Instructional Modules" (IM's) which guide cognitively impaired individuals through functional activities. A specialized computer language called COGORTH (from COGnition ORTHosis) has been written for these applications and is described in an accompanying report. In earlier research, the efficacy of COGORTH IM's was studied with a cognitively impaired patient. This patient was unable to complete many daily life tasks without assistance. However, using a specifically designed COGORTH IM, the subject was able to complete a complex cooking task without error.

Current studies include: 1) the use of IM's to determine whether computerized task guidance and cueing can permit cognitively-impaired people to independently perform a vocational (janitorial) task which they could not otherwise complete on their own. This project will be expanded in the second year to include multiple concurrent tasks; and, 2) the development of IM's for various daily living activities (washing, dressing, food preparation, etc.) for patients in both our inpatient and outpatient rehabilitation programs.

Preliminary Results—Trials with two inpatients have led to marked improvement in their performance of daily activities. There has been some apparent carryover to performance even without computer assistance, although recovery is also playing a large role, as these interventions are being imposed at relatively early stages of rehabilitation.

Future Plans/Implications—Discussions are under way with a number of different centers to establish trials of COGORTH IM's, with a wider range of participants (i.e., geriatric) and environments. Libraries of COGORTH IM's are gradually accruing with each new attempted application. These libraries greatly facilitate development of new IM's, as existing routines can be incorporated either as is, or with modifications, into new cognition orthoses. Another planned effort is to develop an intelligent mobile (i.e., robotic) base which will allow a computerized task guidance system to either follow or lead an individual through his/her environment.

Publications Resulting from This Research

The Microcomputer as an Orthotic Device for Cognitive Disorders. Levine SP, Kirsch NL, Fallon-Krueger M, Jaros LA, *Proceedings of the 2nd International Conference on Rehabilitation,* 130-131, 1984.

The Microcomputer as an Orthotic Device for Patients with Cognitive Deficits. Kirsch NL, Levine SP, Fallon-Krueger M, Jaros LA, *Journal of Head Trauma Rehabilitation,* 1987 (in press).

An Infant Crib for Use by Wheelchair-Bound Parents

Micheal D. O'Riain, Ph.D., P.Eng., and Gilbert Layeux, Reg. Tech.
The Rehabilitation Centre, Ottawa, Ontario, Canada, K1H 8M2

Sponsor: *Rehabilitation Centre: The Royal Ottawa Hospital*

Purpose—The objective of this project was to design an infant crib which could be used by a wheelchair-bound parent. The number of wheelchair-bound persons who are having children has increased the number of demands for such a crib. Conventional cribs are difficult to use by these parents, because it is difficult for them to lower the side and, once lowered, the side keeps the wheelchair at an unsafe distance.

Progress—A prototype crib has been constructed and is currently under evaluation to ensure its safety and to determine its usefulness. The new crib is higher than conventional cribs, to allow easy access by wheelchair-bound persons. The side slides open horizontally, allowing the parent direct access to the infant. Double locks, which engage automatically on closure, prevent accidental opening of the doors.

Future Plans/Implications—Once the new crib is determined to be safe for use with infants, an evaluation will be made with the assistance of wheelchair-bound volunteers and their infants.

Multi-Adjustable Forearm Support Walker

J.R. Linskell, M.Sc., and E.R.C. Draper B.Sc., (Hons) M.B.E.S.
Bioengineering Centre, Princess Margaret Rose Orthopaedic Hospital, Edinburgh EH10 7ED, Scotland

Sponsor: *Scottish Home and Health Department*

Purpose—For cerebral palsied children who cannot support their own body weight through their legs, but are potentially independent ambulators, such as some spastic diplegics, it is normal in this country to employ a Zimmer-type walker with forearm supports to train their gait. The position of support, with the forearms supported horizontally ahead of the child at the high thoracic level, while being relatively stable and therefore reassuring, is far from ideal. It means that the torso is held in a forward leaning position that leads to ungainly and inefficient gait. Far more importantly, however, is the fact that it is not helping to train the coordination required in the muscles of the trunk for balance. An attempt is being made to see if better positioning is possible.

Progress—A multiply-adjustable walking frame has been designed and produced by the Bioengineering Centre. The frame itself is adjustable in three dimensions and the forearm supports are easily adjustable with six degrees of freedom. The device is currently being tested at a specialized school with physiotherapists experimenting with different walker configurations. A protocol is currently being set up for more formal tests to be carried out, that will allow qualification of the different configurations. These will include kinetic, kinematic and electromyograph (EMG) data using a VICON system, as well as Physiological Cost Indices obtained from electrocardiogram (ECG) data that will show the clinical value of such a device.

Walker for the Young Cerebral Palsied Adult

J.R. Linskell, M.Sc., and E.R.C. Draper B.Sc., (Hons) M.B.E.S.
Bioengineering Centre, Princess Margaret Rose Orthopaedic Hospital, Edinburgh EH10 7ED, Scotland

Sponsor: *Scottish Home and Health Department*

Purpose—Many researchers have looked into mobility for the young cerebral palsied child and there are now a number of devices currently on the market that provide different degrees of mobility. As the child develops into a young adult, however, increase in size causes a number of problems that restrict their mobility. Most of the designs available would be unstable with a much larger occupant. There are also the other practical difficulties, in that it becomes increasingly difficult to mount a larger child in such a device, and once there, the extra weight makes it very difficult to support them comfortably. It is intended to produce a walker suitable for this purpose.

Progress—The design is currently underway for a multi-adjustable walker for young cerebral palsied adults. The device will allow the testing of different body orientations and different support regimes to determine the optimum. This will include an investigation into the practicalities of mounting/dismounting such a device. It is intended to quantify the effect of different configurations using full gait analysis and physiological cost indices.

Rehabilitation Engineering Center

Gerald E. Miller and William A. Hyman
Bioengineering Program, Texas A&M University, College Station, TX 77843

Sponsor: *Texas Department of Mental Health and Mental Retardation*

Purpose—This program is designed to provide on-site rehabilitation engineering consultation and service delivery at selected state Mental Health and Mental Retardation (MHMR) facilities in the Gulf

Coast region. It brings University engineering faculty and students in contact with MHMR personnel and clients for the definition, selection, and execution of design projects which will benefit individual clients, serve as a prototyping activity for client devices needed by a group of individuals, or be used with the facility for client treatment or education.

Progress—This report reflects the first six months of the program. Preliminary efforts consisted of meetings at each facility to acquaint the respective staffs with the nature of the program and the types of projects which were consistent with time frames and available resources to produce the designs.

Preliminary Results—Projects to date include the design of a multipurpose adjustable wheelchair frame which could accommodate several devices used by the client. A headwand-operated joystick controller and speech synthesizer were also modified to make them more useful to the client. Seating problems were addressed to provide greater stability to a variety of clients so that other activities and training could be more effective. Several communication devices for non-verbal and motor-limited clients were developed which allow for very simple selection from an intentionally limited menu. A variety of input devices to the communication systems were developed ranging from simple switch activation to foot operation. A similar system for educating developmentally-delayed children was also provided which could accommodate both pictures and real objects for selection by the child at the direction of the therapist. A custom table to accommodate this system was designed and built which provides added stability for the child using the device. Additional projects included an arm-operated aerobic exercise machine, several types of interfaces between client-operable inputs and typical environmental devices, and training devices which provide a reward feedback in the form of operation of a radio or similar appliance. Sheltered workshop task design problems were also addressed to improve worker efficiency and to bring new contracts to the workshop. Non-design activities included general consultation with, and training of, therapists in the application of commercially available rehabilitation and general consumer equipment.

Future Plans/Implications—Early experience with this program demonstrated that there is a significant need for engineering design input for a wide variety of client problems at these facilities, and that many of these needs can be expediently met by a visiting or on-call engineering team. This service delivery model has distinct advantages in that continuous on-site engineering services could not be effectively utilized by these facilities at this time. Moreover, this program brings an array of expertise and experience to each facility as well as the resources of the University for fabricating selected projects. Future plans include expanding the program to cover more state facilities and interfacing the program with newly-developed NSF funding which is aimed at the development and implementation of undergraduate student design projects. As further experience and projects are generated, technology transfer between the needs of the various facilities and short course technology training for on-site therapists will be developed. The broad implications of this effort are that coordination of activities between state agencies can efficiently enhance their programs. For the engineering student, this program provides an opportunity to solve real-world problems, obtain exposure to rehabilitation engineering, and gain a deeper understanding of individuals with handicaps and their needs.

Systems to Enable Physically Handicapped Persons to Board Inter-city Buses

Micheal D. O'Riain, Ph.D.; P.Eng.; Louis Goudreau, B.Sc.A.; Jacques Sibille, P.Eng.; Gilbert Layeux, Reg. Tech.
The Rehabilitation Centre, Ottawa, Ontario, Canada, K1H 8M2

Sponsor: *Rehabilitation Centre: Transport Canada and The Royal Ottawa Hospital*

Purpose—The purpose of this project was to design new systems that would enable physically handicapped persons to board standard inter-city buses. Where possible, the systems were to be sufficiently

portable so that they could be carried in the luggage compartments of buses. However, station-based systems were also to be investigated. Our designs were to encompass as wide a range of inter-city buses as possible.

Progress—The entrances and aisles of inter-city buses are steep and narrow. This represents a major problem for any boarding system to be used by handicapped persons. In designing our systems to get around these constraints, we used the following strategies: 1) The subjects were first transferred from their own wheelchairs to special narrow wheelchairs which would fit through the entrance of the bus and into the aisle as far as the first row of seats. 2) To enable level transfers to be made into the bus seats, and to increase the width of the aisle by a few inches, we specified that the two armrests on the front row of seats be equipped to pivot upwards and out of the way.

Three systems have been designed and scale models have been constructed. The differences between the systems are the methods used to get the user in the special wheelchair from ground level to alongside the front row of seats. Two of the systems are portable and could be carried in the luggage compartment of the bus for use at the destination. The third system uses a permanent ramp and would have to be based at the bus terminal.

Future Plans/Implications—We plan to build full scale prototypes of our designs so that they can be evaluated in use.

Development of a Wheelchair-Accessible Weight Training Gym

S. Naumann, Ph.D., P.Eng.
Hugh MacMillan Medical Centre, Toronto, Ontario, Canada M4G 1R8

Sponsor: *Variety Village Sport Training and Fitness Centre, Toronto, Canada*

Purpose—This study had the following objectives: 1) to design and fabricate a self-contained weight training device which is versatile, accessible to and adjustable by the wheelchair athlete; and 2) to assess the performance of the device at the Variety Village Sport Training and Fitness Centre.

Progress—Wheelchair athletes experience special problems using existing weight training equipment. Awkward equipment adjustments, wheelchair inaccessibility, and lack of user independence often lead to user frustration and discouragement. The weight training device developed for this project is multi-adjustable and incorporates many of the functional features of commercial multi-station gyms. However, this device has the added advantage that safe operation is possible while the user is seated in a wheelchair.

The weight training device consists of a tubular steel frame, a push bar and an adjustable push bar guide, two selectable weight stacks, two pulley system sets and a user safety guard. The frame of the device is free standing and is constructed of 2-inch diameter heavy-walled, cold-rolled steel tubing. This structure is configured to permit the user to enter the rear of the device in a wheelchair and remain in it while lifting weights. At the front of the frame is a weight press bar guided by Delrin bearings on two parallel centerless ground tubes. These guides preclude user injury caused by inadvertent rotation of the push bar. Two locking gas springs are attached to the guides to offset the weight of the guides and to permit the user to adjust the angle of weightlifts over an angle of 90 degrees.

Weights are applied to the push bar through a cable/pulley arrangement by two sets of weight plates located outside the basic frame. Each weight stack contains ten 4-kilogram weight plates. The number of plates lifted by the user is determined by the location of the adjustment pin in each weight stack. The pin has a 1-inch diameter ball attached to its end to ease pin relocation for users lacking fine motor control. The weight stacks are located such that the user can make adjustments without repositioning the wheelchair.

Future Plans—This weight-training device was fabricated in 1987. Assessment of the function of the device will be conducted at Variety Village with the assistance of a number of wheelchair users who will use the equipment regularly for a period of 1 month.

B. Robotics

An Instructable Robotic Aid: A Pilot Proposal

Colleen Crangle; Patrick Suppes; Stefan Michalowski; Larry Leifer
Institute for Mathematical Studies in the Social Sciences, Stanford University, Stanford, CA and Rehabilitation Research and Development Center, Veterans Administration Medical Center, Palo Alto, CA 94304

Sponsor: *VA Rehabilitation Research and Development Service (Pilot Proposal #B942-PA)*

Purpose:—This proposal discusses a vital enhancement to the existing Robotic Aid for the severely disabled. At present, user-communication with this robot is restricted to one-word commands that correspond to predefined primitive actions. Our goal is that this robot understand complete sentences as customarily used by ordinary speakers of English and learn how to perform new tasks as a result of the instruction it receives in English. The disabled user, like most of us, is a computer user not a progammer. If the Robotic Aid were to understand natural English commands and questions, the full power of the robot would be placed in the service of the disabled user.

To achieve our goal, we will apply research in the syntax and semantics of English to provide the Robotic Aid with language-understanding capabilities. Our purpose is to "close the gap" between English and the primitive machine operations of the robot. During the nine-month period of the pilot study, we will: 1) analyze the requirements of a natural-language interface to the Robotic Aid, paying particular attention to the needs of disabled users; 2) identify a set of tasks for the robot that are appropriate to the needs of the physically disabled; 3) formulate a range of English commands for instructing the robot in these tasks and extend the existing natural-language interface for these commands; and, 4) implement a practical application of a prototype system, one that allows a disabled user to communicate with the Robotic Aid in a typical room environment.

This program of work will form the foundation for a long-term joint project that will advance both theoretical work on natural-language interfaces to instructable robots and work on the design of robotic aids for the physically disabled. At the end of this initial nine-month period we will produce: 1) a substantial proposal for long-term research; 2) specifications for an instructable robot system that takes the needs of the physically disabled user into account; and, 3) a demonstration of the preliminary language-understanding capabilities achieved.

Clinical Evaluation of the JHU/APL Robotic Arm

Robert W. Hussey, M.D. and Barry Taylor, M.S., O.T.R.
Veterans Administration Medical Center, Richmond, VA 23249

Sponsor: *VA Rehabilitation Research and Development Service*

Purpose—Computer-based robots can enhance the quality of life for those with high level quadriplegia and other severely motion-impaired people by improving self esteem, reducing the cost of attendant care, expanding avocational and vocational horizons, and providing greater mastery of the physical environment.

This research project was designed to determine the effectiveness of the JHU/APL robotic arm/worktable system performance and to determine the practicality of this system for satisfying the needs of high level quadriplegic persons in attaining independence. The tasks currently being evaluated by spinal cord injured (SCI) patients using the JHU/APL arm include feeding, fetching liquids, tissues, reading materials, a mouthstick, and permitting access to a Mac Plus computer with hard disk drive and to a phone.

Progress—The aesthetics of the robot's movement

and hardware appear to be very significant for user acceptance of this technology. With the JHU/APL robot, a concerted effort has been made to physically approximate a human arm. Also APL has incorporated motion trajectories which often have 3 axes of the arm moving simultaneously (simulating normal human movement), in an effort to make the robot more socially and psychologically acceptable to the user and significant others. This year a 180-degree wrist has been added to the arm, which has increased functional ability and proved very reliable.

Another major consideration in achieving optimum user acceptance is the computer control interface. The APL robotic system utilizes a chin controller which provides the operator a natural extension of his intact motor and sensory abilities. This year, the chin cups have been modified so that they can be custom molded to the face of each individual user.

No knowledge of computer programming is required to operate the robotic arm—the on-board microprocessor is preprogrammed by the therapist to perform complex tasks in response to one or two commands from the user. This preprogramming approach to operation was selected in the interest of user time and energy efficiency, but the operator can assume direct manual control of the arm at any time and interested clients and/or significant others can learn to write their own programs with limited instruction. In March, the EE PROM memory was doubled to allow space for entry of complex programs. Since computers, like robots, are perceived as intimidating by a significant segment of the public, the APL robotic software has been kept very simple and extremely user friendly, minimizing operator training and high tech intimidation. In 1987, the software was modified to remain in the program mode after the completion of a task.

When writing computer programs for a particular operator, efforts are made to "custom tailor" tasks for the specific user as a way of personalizing the robot. For example, in the feeding program, provisions are made to allow for maximum operator control over food presentation, including which type of food is presented, the speed of food presentation, etc. This approach has proved very helpful in maximizing user participation.

A training manual is currently being developed to explain components for controlling the arm, manual operation of the arm, and the function of each individual program in the R.A./WT computer. In addition, a new Air Force headset-type telephone and a large-capacity fluid container are being incorporated into the worktable unit.

Results—Since February of 1987 the robotic arm/worktable has been evaluated extensively by male persons with quadriplegia between the ages of 21 and 60. The length of time from the date of their injury ranged from 1 to 10 years. The levels of injury ranged from C1 to C5. All of the users found the experience restored their sense of independence and self worth; these operators all expressed a desire to purchase a unit of their own if one were available. The tasks rated as most beneficial were feeding, fetching fluids, and accessing the personal computer and the phone. Negative comments centered around the incompleteness of the toothbrush and hairbrush programs. No safety problems have been encountered. The wheelchair-mounted chin controller is preferred to the table-mounted controller for operation of the arm as it affords independence in coming and going from the workstation.

Future Plans/Implications—Plans for the future include the commercial manufacture of 15 robotic arm/worktables, which will undergo acceptance testing at selected VAMC/SCI centers throughout the country, and the evaluation of the first commercial arm at VAMC Richmond. Concurrently, the VA will develop training materials for therapists and veterans who will work with the arm. A joint project is just under way which will marry the computer hardware and software from the VA/Stanford University program with JHU/APL robotic arm, with evaluation of this generation prototype to be conducted at Richmond VAMC.

Application of a Robotic Aid for the Severely Physically Disabled

Larry J. Leifer, Ph.D. and Inder Perkash, M.D.
Veterans Administration Medical Center, Palo Alto, CA 94304

Sponsor: *VA Rehabilitation Research and Development Service (Project #B239-2RA)*

Purpose—The long term goal of the project is to enhance quality of life for the severely physically disabled by providing increased independence in functioning through the use of robotic aids.

Specific objectives of the project are to: 1) place and evaluate the stationary robotic aid in the home or office setting for both personal and vocational applications; 2) continue upgrading a second similar prototype system in the clinical setting at the Palo Alto Veterans Administration Spinal Cord Injury Center, based on feedback from in-home, in-office and rehabilitation application; 3) develop a flexible production prototype workstation for individualized in-home and in-office application with the stationary robotic arm; 4) define capabilities and limitations of such a system, with recommendations and instructions for use (user manual); and, 5) define specifications for an acceptable, cost effective desk top robotic aid, and meet those specifications, in order to maximize the likelihood of wide-spread utilization of robotic aids by the severely disabled.

Evaluation of a Desk-Top Robotic Aid with High-Level Quadriplegics

Larry J. Leifer, Ph.D.; Inder Perkash, M.D.; H.F. Machiel Van der Loos, EDME; Joy Hammel, O.T.R.; David Lees, M.S.
Rehabilitation Research and Development Center, Veterans Administration Medical Center, Palo Alto, CA 94304

Sponsor: *VA Rehabilitation Research and Development Service*

Purpose—A third-generation desk-top robotic assistant for high-level quadriplegics has been developed and clinically evaluated during the past year at the Palo Alto VA. Based on user operation of our previous prototype systems, we experienced a need to formalize the data-collection process during test subjects' use of the robot system. Comparing results from the pre- and post-test questionnaires which were used in the evaluation of the second and third generation systems gives us a valuable means of tracking our progress. Ultimately, results from these questionnaires will be used, in conjunction with quantitative performance assessments during task performance, to define future needs in enhancing the robot, user interface software, and task environment.

Progress/Methodology—The clinical evaluation staff have, for many years, used empirical data and user impressions to provide feedback to the developers, for the purpose of continuing system improvement. In addition, data collection during subject use of an earlier speech-recognition device led us to identify many significant facets of user performance related to voice control of the robotic assistant. Our current attempt to formalize the testing process represents a next step in quantitative analysis of performance and consistent data collection of user feedback.

The robot system we are using represents an evolutionary step from last year's desk-top system. The study protocol has been stabilized, and twenty quadriplegics (levels C3-C5) have been tested with our desk-top robot. Pre-tests were given before a one-hour introductory orientation. The post-tests were given after a two-hour training session, during which the quadriplegics used the robot to perform tasks such as washing the face, shaving, brushing teeth, preparing a meal and eating it with utensils, and operating an environmental control unit to turn a radio and lamp on and off. Task assessment was evaluated by measuring completion time, subjective user satisfaction, and overall robot performance.

Preliminary Results—The pre- and post-tests administered to the twenty subjects inquire, for example, about the user's reaction to the robot's appearance, "personality," noise level, ease of learning, safety, obedience, monetary worth, and reliability. Post-

tests were uniformly more positive than pre-tests, and results on our third-generation desk-top system were uniformly more favorable than those pertaining to the older system. The task performance results confirmed the disabled user's ability to successfully complete activities of daily living using the robotic assistant.

Based on feedback from users, the robot is systematically upgraded to incorporate new tasks and to enhance the user interface. Our goal is to make the system easier to use and understand, in order to decrease user frustration and shorten the learning time needed to become proficient in using the robotic assistant.

Future Plans—In response to a need for more objective user performance measures, the current study will form the basis for a complete assessment protocol or the evaluation of future robotic assistants. The assessment will be largely automated, with the robot's controller being responsible for data gathering and will permit the development staff to track performance during typical usage. This represents a valuable and even more powerful means to quantify user acceptance of the technology, and to identify and quantify shortcomings, usage patterns, and needed future enhancements in the software and hardware of the system.

Design of a Desk-Top Environment for a Robotic Aid for the Severely Disabled

Larry J. Leifer, Ph.D.; Inder Perkash, M.D.; H.F. Machiel Van der Loos, EDME; David Lees, M.S.; Joy Hammel, O.T.R.
Rehabilitation Research and Development Center, Veterans Administration Medical Center, Palo Alto, CA 94304

Sponsor: *VA Rehabilitation Research and Development Service*

Purpose—The desk-top robotic aid is a state-of-the-art voice-controlled manipulation system to allow quadriplegics to pursue daily living and vocational activities. With previous prototypes, the degree of reliability and performance limitations have prevented us from attaining an acceptable level of system reliability for the robotic assistant to be evaluated outside the research laboratory. Advances in speech-recognition technology and commercial computer hardware and software have improved the user interface to the system's PUMA-260 robot manipulator significantly. The current generation of the robotic assistant can be confidently used in a clinical laboratory environment with minimal engineering support. From a system reliability standpoint, this robotic assistant can be expected to perform satisfactorily outside the clinic in a variety of locations.

The refinement of the user interface software over the past year has made the system easy to use and reliable for the tasks already programmed. Continuing studies in our clinical environment will ready the desk-top robot for formalized evaluation at other locations.

Progress—Many elements of the robotic workstation have been changed or improved over the past year to increase overall performance. A commercial prosthetic hand, the Otto-Bock Greiffer, has replaced a simple prototype gripper. A VOTAN combined speech recognition and digitizing system has replaced an earlier generation of voice I/O hardware, and has resulted in significant improvements in speech recognition, in quality of speech feedback, and in reduction of user frustration. A new table-top environment has been designed using a fixed, easily modified tool holder in place of the large, rotating kiosk. This change has increased the robot's speed and reliability in retrieving objects. The aesthetically pleasing, wheelchair-accessible table-top robotic assistant has made the system well-suited to the clinic environment.

Software in the past year has progressed on four fronts. First, the integration of screen-based help menus and voice feedback to inform users of specific events, is complete. Second, task programming in the robot language VAL now includes at least 10 tasks spanning activities of daily living and simple clerical functions. Third, there is a complete protocol for synchronizing VAL programs with the user interface software. This is a very important step in making task programming self-explanatory to the user through the coordination of screen menus and safety warnings, and in making existing tasks easy

to modify by programmers. Fourthly, all user commands and robot actions are automatically recorded by the controller, so that subsequent data inspection and reduction by the staff can be used for future performance enhancements.

Preliminary Results—Based on testing with 20 quadriplegic users from the Palo Alto VA Spinal Cord Injury Center, the new system is perceived as being easier to use and more reliable than previous systems. Also, the number of breakdowns and malfunctions noted by clinical and engineering staff has been significantly lower with this system than with previous ones.

As an added feature, the robot system is composed entirely of off-the-shelf components, except for the task environment, which varies with the application, and several minimal modifications to the robot and controller, such as gripper wiring. The entire robot manipulator, as well as computer hardware and system software, are robust, industrial products.

The research and development of our team can be viewed to a very large extent through the design of the user interface software: this very crucial entity represents many man-years of work and is now a very refined software package. It combines speech recognition and feedback, a well-designed graphics display to cue the user on possible commands and allowable actions, a sophisticated interface to the robot's own motion controller, and the ability to actuate an environmental controller and a modem.

Future Plans—The ongoing aim of the system design effort is to further refine the user interface software. Our immediate goal is to make it easier for the programmer to develop new tasks and add them to the robot's repertoire. Ultimately, users themselves could write and install complete tasks without extensive programming skills. This need is becoming increasingly important as the system is placed in off-site work and home settings where constant programming support is not available to users.

Development of a Mobile Robotic Aid for the Severely Disabled

Larry J. Leifer, Ph.D.; Inder Perkash, M.D.; Stefan J. Michalowski, Ph.D.; H.F. Machiel Van der Loos, EDME
Rehabilitation Research and Development Center, Veterans Administration Medical Center, Palo Alto, CA 94304

Sponsor: *VA Rehabilitation Research and Development Service*

Purpose—During the past years, a number of projects have explored the potential use of robots as assistive devices for the severely disabled. Using funds provided by the US Veterans Administration, the Robotic Aid Project has developed three prototype systems. The latest of these is a voice-controlled mobile manipulator consisting of a commercial robotic arm equipped with sensors and mounted on an omnidirectional vehicle. The purpose of the current research effort is to adapt the robot for everyday tasks that a disabled person may wish to perform in a home or institutional residency environment.

Progress—The Mobile Robotic Aid currently consists of two major components: an omnidirectional mobile manipulator and a stationary operator console. The robot is intended to perform efficiently in a relatively unstructured environment, i.e., one that does not require extensive modifications from a typical homelike setting. The Mobile System accepts spoken commands, including commands that refer to movements of the vehicle. Because of the additional three degrees of freedom associated with mobility, a dedicated color display has been implemented to assist the user in keeping track of the instantaneous state of motion of the robot. Another screen shows the location of the robot with respect to a two-dimensional map of the surrounding area. A third screen shows a black-and-white video image from a small camera mounted on the robotic arm.

Any configuration of the arm can be labeled by the user by assigning a number. Trajectories can then be assembled from the labeled configurations using a special set of spoken commands, and the trajectories can be executed at any later time with a single command. Vehicle locations can be labeled simply by designating them on a computer display, using an ultrasonic head-position detector that moves a cursor on the display in response to forward-

backward and sideways head motion.

Because the robot has no *a priori* knowledge of the environment, four sensor subsystems have been developed to enable the mobile robot to function efficiently without imposing an unreasonable control burden on the user:

1) A segmented touch-sensitive bumper system surrounds the mobile robot.

2) A low-power laser scanner is mounted on the side of the vehicle. By detecting the presence of reflectors that are placed at known locations in the robot's environment, the scanning routine can compute an accurate position and orientation of the robot.

3) A set of photoelectric proximity sensors are built into the robotic hand. A variety of voice-activated routines are available to the user to detect objects near the hand and (to a limited extent) to grasp those objects automatically.

4) A force-sensing wrist measures forces and torques between the hand and the arm. Project personnel are in the process of developing application routines such as pushing a button or stirring liquid in a cup.

Over the past year and a half, a preliminary natural-language interface was implemented for the mobile robot. Typical commands understood (and executed) by the robot are: "Go to the desk; Then go on over to the telephone when the bumpers are hit; Slowly move backwards to within one inch of the stairs; Go northwest for three feet then face the chair." This work did not aim for broad syntactic coverage, nor did it attempt to take into account the role played by the robot's perceptual functioning in the interpretation of commands. Rather, it concentrated on the design of a basic control architecture for a commandable robot.

Future Plans—During the next period of design and research activity, a fully-functional prototype will be delivered to the VA Medical Center for clinical evaluation. Numerous hardware and software refinements will be made to ensure safety and reliability.

Robot Arm/Work Station System for High Spinal Cord Injured Persons

W. Seamone, B.A.E., and G. Schmeisser, M.D.
The Johns Hopkins University Applied Physics Laboratory, Laurel, MD 20707

Sponsor: *VA Rehabilitation Research and Development Service*

Purpose—The goal of this continuing research is to complete the basic development of a working model of the robotic arm/workstation system to permit manufacturing a limited number of units at low cost, so that they may be placed in selected VA Spinal Cord Injury Centers. In order to obtain realistic data by quadriplegic users, the latest upgraded system was delivered to the VA Medical Center at Richmond, Virginia, late in 1986.

Selected quadriplegic patients have been evaluating the system to determine its usefulness for tasks such as self-feeding, reading, using a telephone, tooth brushing, and other tasks of daily living. Such evaluation can provide information on patients who would best benefit from the system, and can help develop training procedures for those who will use the system. These tests are proceeding.

This workstation has been designed with the specific goal of allowing total task accomplishments in complete safety and with little or no attendant assistance. The system is currently operated via a chin controller located on the workstation; future plans include the examination of the use of the voice input front-end that was developed for the VA Palo Alto Robot program.

The role of the Applied Physics Laboratory (APL) during the past year has been one of fine tuning the engineering design details, assisting VA Richmond in test procedures and table equipment layout, and helping the VA prepare specifications for a commercial unit. This report summarizes some of the equipment modification concepts explored, and current plans for manufacturing.

Progress—The original robot arm/work table was designed to be controlled via a dual-purpose chin controller mounted on the wheelchair. While this design worked well for certain patients who could utilize an E&J wheelchair compatible with the controller, the concept lacked flexibility for patients with other models of wheelchairs. A table-mounted chin controller was subsequently developed to pro-

vide an alternative to the chin-operated controller. This unit is currently undergoing evaluation at VA Richmond. To further enhance the input capability, voice input is now considered as an alternative. Preliminary investigations have been made of the possibility of adapting the voice input system developed for the VA Palo Alto Robot to the APL robot arm. A demonstration is planned to verify the feasibility of this arrangement.

One new task that was added to the workstation was a tooth brushing arrangement. For this task, a disposable toothbrush with precharged toothpaste is used. The robot arm can pick up this device, squeeze the brush to make toothpaste flow to the bristles and then brush the quadriplegic's teeth, using several preprogrammed trajectories to reach different parts of the mouth. Preliminary testing indicated this program did a reasonable job of tooth brushing.

An important task on the workstation is using a personal computer. The two input techniques primarily utilized in earlier models were a mouthstick or a chin-operated Morse code keyer. These early workstations utilized an APPLE II+ or an EPSON QX-10 computer. In the most recent evaluation at VA Richmond, a MAC Plus computer with 20 megabyte hard disk was installed on the table, with a special sip/puff transducer serving as the equivalent of a mouse for high level quadriplegic users. This system is currently being evaluated and preliminary results look very encouraging.

A preliminary examination has been made of a ceiling-mounted track suspending the robot, to allow the robot arm to transverse to 3 or more workstations. Such a system would allow each work area to be optimally designed for a single task (i.e., self-feeding). The user could command the robot to travel to various parts of the room to the desired work area. Voice-control input is the most likely candidate for control input. One solution to the power supply problem for such a system would be to use high-energy-density rechargeable batteries located in the robot arm, and provide trickle-charging via a low AC voltage applied to the track. It is estimated that the existing robot arm could be suspended from a ceiling track with only minor modifications to its mechanism.

This year's work includes only preliminary system design layout of these alternatives. No hardware mockups are planned at this time.

Future Plans—The APL robot arm/work table was selected by the VA for transition into a manufacturing prototype. Such a model has been designed, one unit constructed and evaluated. This first system did not perform adequately and was subsequently repaired and modified at APL to bring the unit into a functional operating condition. The VA has since decided to write a new specification and release the design for bids by companies for manufacture of 15 units. It was anticipated that this RFQ would be available for industry sometime during the fall of 1987.

A Robot Feeder

Micheal D. O'Riain, Ph.D., P.Eng.; Jacques Sibille, P.Eng.; Louis Goudreau, B.Sc.A.
The Rehabilitation Centre, Ottawa, Ontario, Canada, K1H 8M2

Sponsor: *Rehabilitation Centre: The Kinnear Foundation and The Royal Ottawa Hospital*

Purpose—The objective of this project was to design a Robot Feeder for use by severely physically handicapped persons who could otherwise not feed themselves. The advantages of the Robot Feeder to such persons would be increased independence and self-esteem. A microprocessor controller is used with our system to simplify the control of the unit, to improve the reliability of picking up food, and to bring the food safely to the mouth.

Progress—A prototype Robot Feeder was constructed and evaluated to determine its ease of control, ability to pick up food, reliability in bringing food to the mouth, speed of operation, noise, and safety. The first prototype was found to be effective in picking up food and bringing it to the mouth. However, it was felt to be too slow and to have an unsafe amount of backlash. For these reasons, the first prototype has not been given to any of our physically handicapped clients for trial.

Future Plans/Implications—The Feeder is being redesigned to correct all of the problems encountered with the first prototype. Backlash will be reduced by replacing the chain drive with a lever drive and by reducing the number of joints. "Fail Safe" systems will be installed to insure the safety of users in the event of a system failure. Machine vision, to assist the system in locating the food and the mouth, will be added at a later time.

The following summaries are selected and reprinted with permission here from *Interactive Robotic Aids—One Option for Independent Living: An International Perspective*, Monograph 37, published by the International Exchange of Experts and Information in Rehabilitation, World Rehabilitation Fund, Inc. All of the reports from U.S. contributors were first submitted to RESNA (Association for the Advancement of Rehabilitation Technology) and were presented at a Symposium on Interactive Robotics during the RESNA 1986 Annual Conference in Minneapolis, Minnesota. Full text of these selections and others contained in the monograph are available by writing to the World Rehabilitation Fund, Inc., 400 East 34th Street, New York, NY 10016.

Spartacus and Manus: Telethesis Developments in France and in the Netherlands

H.H. Kwee, Ph.D.
Institute for Rehabilitation Research, 6432 CC Hoensbroek, The Netherlands

Sponsor: *Institute for Rehabilitation Research*

Progress/Results—The Spartacus project was a five-year robotics project, intended to stimulate industrial robotics in France, in which a "unifying theme" was selected to be a feasibility study aimed at the development of a telemanipulator controllable by persons with high-level spinal cord lesions. A telemanipulator system was realized in two phases: first as a simulation with a commercial arm used in nuclear research controlled by a mini-computer and then by a specially developed manipulator, derived from the first one, with micro-computer control. From very early in the project, much attention was paid to control ergonomics, with the participation of a number of disabled volunteers in laboratory experiments. After the formal termination of the project, studies with various disabled persons have continued in a hospital environment.

The Dutch "Manus" Project is aimed at the development of a manipulator as a product which may be provided to disabled persons as an assistive device at an acceptable price (through some form of social security benefit). Following a one-year feasibility study, the Project officially started in 1984 with Dutch government funding for a two to three year period as a collaborative effort between four R&D institutes:

Institute for Rehabilitation Research (Hoensbroek), principal contractor in charge of over-all project management problem definition and product specification, human factors, contacts with potential users and (para-)medical personnel, cost/benefit analysis, etc.;

Institute for Applied Physics-TNO (Delft), in charge of system design, electronics and software development;

TNO Product Centre (Delft), in charge of electromechanical hardware development, cosmetic design, and industrialization of the system;

Netherlands Institute of Preventive Health Care TNO (Leiden), participating in a socio-economic cost/benefit analysis.

The product development is being realized by the first three institutes in very close interaction. This is necessary in order to optimize the over-all system; integrating mechanical, electro-mechanical and computer hardware, compromising between hardware and software solutions, and compromising between feasibility and costs of technological solutions on the one hand and user specifications (including functionality, cosmetics, safety and human factors) on the other hand.

The first phase of the project, now under way,

will serve to realize a first model to verify the different hardware and serve to control concepts adopted and the acceptability of the compromises agreed upon. Further development towards a product will depend upon the outcome of the (technical) evaluation of this model, which will verify the feasibility of the objectives of the MANUS Project.

A Potential Application in Early Education and a Possible Role for a Vision System in a Workstation Based Robotic Aid for Physically Disabled Persons

W.S. Harwin; A. Ginige; R.D. Jackson
Department of Engineering, Cambridge University, Cambridge, United Kingdom

Sponsor: *Milly Apthorp Charitable Trust*

Purpose—At the Cambridge University Engineering Department we are investigating the use of robots to assist in the developmental education of handicapped children. The robot used in this project is the RTX manufactured by Universal Machine Intelligence LTD, London. The robot is based on a SCARA format and is, to our knowledge, the only robot with design considerations given to applications for disabled in addition to those of light industry. It has a full 6 degrees of freedom, a 1000 mm range and a load capacity of about 2 kg. A vision system is added to the robot as are gripper sensors and we hope for an eventual cost of about £10000. Although this cost is comparatively high, it is justified to keep flexibility and safety in a wide range of potential applications. The intention is to keep a flexible range of user input systems and use sensors and vision to minimize the information that must come from the user. This project is in developmental stages so success cannot be measured by commercial sales; however, other indicators are possible.

Progress—One substantial clinical trial has been made so far in which three learning tasks were investigated. Two of the tasks were suggested as basic developmental tasks that are not achievable by children with severe physical disability, yet are central to their education. These were a routine to stack bricks in a pile and break the pile once built, and a routine to sort bricks into boxes depending on their shape or color.

The third task was the Tower of Hanoi puzzle that consists of a tower of discs with decreasing diameters which must be moved to a second location with the rules that only one intermediate location can be used and at no time can any disc be placed on a smaller disc. The robot enforced these rules but gave the user control over moving discs.

Preliminary Results—Everyone enjoyed working with the robot and it would appear to have a potential impact on someone who would not normally have done such tasks. The robot provided experiences about sounds and dimension in life. We believe this shows a potential for robots in education and would like to suggest a similar configuration for other applications. Future work hopes to expand the vision to increase field of view and possibly use it to identify unmarked objects to the robot. A more sophisticated robot control language is envisaged that would take advantage of sensor information and information in a database.

Manipulative Appliance Development in Canada: Neil Squire Foundation Project

William Cameron
Neil Squire Foundation, Vancouver, Canada

Sponsor: *Neil Squire Foundation*

Purpose—The Foundation robot project started in 1982 with a thorough study of the history of medical robotics, followed by six months of data collection, mostly through interviews, with many severely dis-

abled, rehabilitation professionals, workers compensation and insurance claim groups and extended care workers.

The specifications for the first model are: 1) mass produced sales price of arm and stand-alone control electronics under $5,000; 2) both master/slave and programmed operating modes; 3) programming to be done on any home computer. An Apple II was selected for the first prototype, and an IBM PC is being prepared for the second; 4) complexity of service and maintenance to be kept simple enough to allow for local consumer audio or computer agency servicing; 5) operation to be extremely user friendly, with no operator training being required. Specifically, no knowledge of computer programming will be necessary, and no computer keyboard will be used; 6) the coordinate envelope is approximately human-sized; 7) the appliance must be portable, with total weight to be less than 20 kg; 8) lifting capacity at worst geometry of 1.4 kg, and at most geometries of 2.3 kg; 9) use in industry in light manufacturing to be underscored.

Progress—The robot (M.O.M., a Machine for Obedient Manipulation) is designed as a work station manipulator in which the disabled user travels to the workstation (by wheelchair) and the arm operates as an attendant. M.O.M. is mounted at about eye level (to one sitting down) and can, by program, perform manipulations for tasks such as: 1) picking up a manual from a bookshelf and placing it in front of the individual; 2) turning pages; 3) picking up, serving and replacing a drink; 4) serving up a mouthstick; 5) loading a diskette in the computer; 6) picking up an electric razor and shaving a person; 7) brushing hair; 8) brushing teeth.

The TRIUMF/NEIL SQUIRE robot development to date has leaned toward fully programmed tasks with standard environmental control interfaces. It is our goal to find a suitable combination of disabled user control and programmed control that will provide performance that is user-acceptable.

An Independent Vocational Workstation for a Quadriplegic

Caroline Fu
Artificial Intelligence Center, Boeing Computer Services, Seattle, WA 98124

Sponsor: *Boeing Computer Services*

Purpose—Phase 1 of this project, which began in early 1984, initially focused on providing a speech-controlled workstation that could be used by programmers and analysts and on voice control over data later in October. We believe that if a workstation can be built for a programmer, others might be able to adapt it to satisfy the specific needs for other professions such as financial analysis, engineering, and manufacturing.

Phase II of this project, started to consider that a quadriplegic individual, when using the workstation, might impose a burden to co-workers in the environment in which the unit was to be placed. The physically-limited person could not handle such routine functions as referring manuals, retrieving printed output, loading a diskette into a disk drive without assistance, etc. The voice-controlled robotic aids were then added to the workstation.

Results—The workstation that is in use now has a microcomputer system that supports and is driven by two voice recognition products and a voice communication product. The microcomputer is an IBM PC XT. This unit is capable of emulating different terminals which give access to multiple vendors' mainframe products. Besides, there is also a greater freedom of selection amongst voice products for the IBM PC. The voice communications product comes from Dialogic, and the voice recognition products from Keytronic and Microphonics. By April, 1986 the workstation and its operator were fully functional in a business programming environment. The operator was completely independent of supportive aid from co-workers.

Small Robot Arm in the Workplace to Aid in the Employment of Severely Physically Disabled Persons

Leonard L. Anderson, M.S.E.M.
Cerebral Palsy Research Foundation of Kansas, Inc., Rehabilitation Engineering Center, Wichita, KS 67208

Sponsor: *National Institute on Disability and Rehabilitation Research and Wichita Rehabilitation Engineering Center*

Progress—The Rehabilitation Engineering Center in Wichita, Kansas, has, as its emphasis, research in the area of finding means to place severely physically disabled persons in the workplace through the use of technology. A project to investigate the use of small robotic arms to assist the disabled at work has been underway for three years at the time of this writing. Several types of devices were investigated and evaluated prior to purchase. Two such types representing two distinct operating and programming criteria were purchased and have been in use on the job.

The purpose of the project was to choose a workstation which would be suitable for robotic application in the area of manipulation of workpieces, but, would also require the support of a worker in the area of quality control inspection and indexing of workpieces for the start of each operating cycle. The worker should also be able to stop the operating cycle should problems arise. It was anticipated that a severely physically disabled person could then work at this station utilizing the robotic arm to perform the precise manipulations of small parts while, at the same time, exercising quality control (inspection) and the indexing of parts for the operating cycles.

The research project goals were to investigate devices that provided for the most articulation so that fine motor tasks could be investigated. The workstations that were chosen require the capability of the fully articulated "arm." Therefore, a more thorough investigation of robotic arm capabilities was possible.

The author and other researchers on this project have concluded that the concept of employing severely physically disabled persons by the use of small robotic arms has been shown to be viable.

CALVIN: A Robot Control Language for Rehabilitation Robotics

Scott L. Minneman and Thanh Pham
Rehabilitation Engineering Center, Tufts University/New England Medical Center Hospitals, Boston, MA

Sponsor: *Rehabilitation Services Administration, U.S. Department of Education*

Progress—A new control language has been developed for use with small, microcomputer-controlled robotic manipulators. The language was specifically designed for use in rehabilitation settings. Particular attention has been paid to the user interface, programming environment, portability of programs, and extensibility. The language has been introduced and well accepted for use at two clinical sites investigating occupational applications of small robotic manipulators. Application program development time has been drastically reduced and the language has permitted the robots to be used with clients for whom a suitable interface could not previously be found.

CALVIN is a fully functional robot control language that offers its users numerous benefits over the languages traditionally supplied with the purchase of a microcomputer-controlled manipulator. Clinical trials are demonstrating that the language is robust, easy-to-learn, and extremely useful for developing rehabilitation robotics applications.

C. Communication Methods and Systems

A Systematic Analysis of Communicative Interaction Between a Nonspeaking Physically Disabled Child and a Speaking Peer: Pilot Study

P. Parnes, B.Sc., D.S.P.A.
Hugh MacMillan Medical Centre, Toronto, Ontario, Canada M4G 1R8

Sponsor: *Augmentative Communication Services, Hugh MacMillan Medical Centre*

Purpose—The objective of the pilot study was to investigate the quality of communicative interaction between one nonspeaking physically disabled child and a speaking peer without the presence of an adult mediator. Specifically, the study described the turn-taking abilities, topic initiation and maintenance, communicative functions and communicative modes of both children.

Progress—Two children were selected from the intensive therapy unit at the HMC School using the following criteria: 1) a nonspeaking, congenitally physically disabled child who directly accesses his/her augmentative system and has had access to this system for at least four to six months; and 2) a speaking, physically disabled peer who is of similar age and cognitive level to the nonspeaking child and who does not have any major language, vision or hearing deficits.

The interaction between the two children was videotaped for ten to fifteen minutes on three separate occasions over a period of ten school days in a free-play situation in a simulated playroom at the Augmentative Communication Service. The children were asked to play together for a short period while the investigator was "busy." The videotaped interactions were transcribed in their entirety following procedures used by Tannock (1983) and Light (1985) in previous studies of interactions between young children and their primary caregivers. The written transcripts were coded to examine turn-taking, topic negotiation and the communicative functions and modes used by the children.

Results—The data from the three videotaped samples of interaction were similar, indicating a relatively stable pattern of interaction. Results suggested that although the interaction was highly transactional with the two children influencing each other, it was highly asymmetrical. Exchanges were initiated and maintained primarily by the speaking child who contributed approximately twice as many turns and three times as many initiations as the nonspeaking child. The latter child was highly responsive, but often produced minimal responses such as eye gaze to the partner even though he had the ability to vocalize and gesture with head and hands. Most of his communicative turns consisted of confirmations, denials and protests, conveyed by means of vocalizations, gestures, and facial expressions; these nonpropositional messages were conveyed effectively and efficiently with these modes. On no occasion was the nonspeaking child observed to use his communication board with his peer, although the speaking peer was reportedly able to read many of the larger print words above the Blissymbols. It is of note that when the investigator interacted with the children before and after the observation sessions, the nonspeaking child frequently expressed his messages via his board in conjunction with other modes.

Future Plans/Implications—The results suggest that peer interactions of nonspeaking physically disabled children may be problematic, requiring intervention. These results require replication with a larger group of nonspeaking physically disabled children to establish their external validity.

Assessment of the Effectiveness of a Small, High Quality Speech Synthesizer in Augmenting the Communication of Non-Speaking Individuals

Rob E. Garrett, B.Tech.; Cathy F. Olsson, B.App.Sci. (Speech Path.); Barry R. Seeger, Ph.D.
Rehabilitation Engineering Department, Regency Park Centre for Young Disabled, Kilkenny, S.A. 5009 Australia

Sponsor: *Channel 10 Children's Medical Research Foundation of S.A.*

Purpose—Significant resources are now available to non-speaking individuals who can afford to purchase communication devices priced in the range $A3,000-$A7,000 and who have the physical and cognitive ability to access these devices. These comprehensive devices enable a user to type a message using a keyboard; or select words and sentences using symbols or codes and to have them spoken. The significance of these devices in augmenting the communication of non-speaking individuals is now well established.

Even though these devices have been available for a number of years, there are still a significant number of non-speaking individuals who are unable to use them because of cost or accessing problems. There is a perceived need for a small and relatively inexpensive speech synthesizer that is portable and can be easily attached to a wheelchair or near a user. This simple device would have 1 to 8 switches which would enable immediate access to a spoken message.

The aims of this project are: 1) to assess the effectiveness of the provision of a device with a limited number of phrases, on the communication interaction of non-speaking individuals whose physical or cognitive accessing skills do not allow them to operate other speech synthesis devices; and 2) to demonstrate that the development of a simple low-priced speech synthesizer would be of value in increasing communication interaction.

Matching of Computers and Interfaces to the Needs of Tetraplegic Patients

D.S. Workman and C.G. Geggie
Spinal Unit, Edenhall Hospital, Musselburgh, East Lothian EH21 7TZ, Scotland

Sponsor: *Committee for Research for Equipment for the Disabled, Scottish Home and Health Department*

Purpose—The project aims were: a) To establish the needs of tetraplegic patients, particularly those with spinal injuries, to use microcomputers; b) to apply and evaluate alternative input devices emulating the keyboard of a BBC model B microcomputer; and c) to produce guidelines relating to safety and interconnection standards.

Progress—Five alternative input systems were evaluated. These systems represented the three methods of keyboard character selection: scanning, coding, and direct selection. The first year was spent formally assessing the use of the five alternative input systems with tetraplegic patients. The subjects learned how to use the device, then underwent a typing test. East subject was then given a choice of equipment for long-term evaluation.

During the second year, methods of increasing speed of communication were explored. Interconnection and safety standards were investigated. Work was done to increase interconnection compatibility in order to encourage a modular approach to the design of alternative input systems.

Preliminary Results—a) Currently available alternative input devices are not meeting the needs of most spinal cord injured people with a high level injury. b) Independent access and control of such equipment is important for this population, as well as a system allowing faster input speed. c) Currently available equipment is beyond the financial resources of many spinal cord injured people. Financial assistance is required to enable computer skills to develop. Initially, this could be with the alternative input device itself. d) There is a need for standardization of interconnections. e) Predictive systems appear to be of most use to people with a very slow operating speed. f) To ensure full use of

the equipment, skilled assessment and follow-up are essential.

Future Plans/Implications—It is planned to develop a system incorporating a variety of alternative input systems configured to allow rapid interchanging of system modules. This system will allow therapist and client to experiment with different module configurations unhindered by interconnection incompatibilities.

Evaluating the Effectiveness of Direct Client Intervention and Facilitator Training for Communication Intervention with Nonspeaking Physically Disabled Children

P. Parnes, B.Sc., D.S.P.A.
Hugh MacMillan Medical Centre, Toronto, Ontario, Canada M4G 1R8

Sponsor: *Easter Seal Research Institute, Toronto, Canada*

Purpose—The goal of this project was to evaluate, through successive implementation, the effectiveness of a two-phase intervention program on the communicative interaction of nonspeaking physically disabled and multi-handicapped children and their parents, and to provide follow-up data two months post-intervention.

Progress—Six subjects were selected to participate in the study from the list of clients newly referred to the Augmentative Communication Service (ACS) and on the waiting list for services. Criteria for subject selection was as follows: a) congenitally physically disabled; b) nonspeaking; c) ages between three and ten years; and d) vision and hearing deemed adequate for the development of an augmentative communication system. The research project explored the cumulative effects of successive implementation of two phases of intervention procedures on communicative interaction between the children and their parents. The children and their parents were videotaped on four separate occasions: l) baseline; 2) following direct intervention with the child; 3) following facilitator training on a group and individual basis; and 4) two months post-intervention. The videotaped interactions were transcribed and coded according to procedures developed by Light (l985). The coding data for each of the three variables (i.e., discourse status, communicative function and mode of communication) were analyzed to determine the effect of intervention on the children and their facilitators, as well as the long-term effect two months post-intervention.

Results—Five of the six dyads showed increased reciprocity in their turn-taking patterns from initial observations upon referral to the follow-up session two months after intervention. The children in each of these dyads contributed to a greater proportion of the total turns in the interactions after intervention than they did before intervention. In fact, three of the dyads approached a perfectly symmetrical balance in their turn-taking patterns by Session 4.

The children's rates of turn-taking in four of the dyads: these increases ranged from 2.8 to 9.3 additional turns per minute. The parent's rates of turn-taking remained fairly consistent. However, the rates of responses for four of the parents increased from Session 1 to Session 4. In fact, there seemed to be a clear relationship between the child's rate of turn-taking and the parent's rate of responses.

Future Plans/Implications—The development of reciprocal turn-taking skills provides a foundation for the children's later development of more complex interactive and linguistic skills. Further research is required to evaluate the relative impact of various approaches to child intervention and parent training.

Towards Universality of Access to Information: Systems Software to Aid Access to Microcomputers by Physically and Multiply Disabled Students

B. Borthwick, Ph.D.; J. Bowles, B.A.; M. Milner, Ph.D., P.Eng., C.C.E.; P. Parnes, B.Sc., D.S.P.A.; S. Jarvis, B.Sc., P.T.; S. Naumann, Ph.D., P.Eng.
Hugh MacMillan Medical Centre, Toronto, Ontario, Canada M4G 1R8

Sponsor: *Ontario Ministry of Education, Canada*

Purpose—The Icon computer is one of two microcomputer systems that meets the functional requirements of the Ontario Ministry of Education for Grant Eligible Microcomputer Systems (GEMS). These requirements were drawn up by the Ministry to stimulate the development of network-based microcomputers designed explicitly for use in educational environments (schools, colleges). The purpose of this project is to create and evaluate an interface board that will enable physically disabled students, who cannot use the Icon keyboard and/or trackball, to access the Icon via alternative keyboards, switches, and an alternative cursor control device.

Progress—The specific goals of this project are to evaluate the Icon as is: to design and build a prototype interface that will allow for transparent connection of definable keyboards, MOD and alternative keyboards, single and multiple switches, and an alternative cursor control device; and to evaluate the interface and the operation of the adaptive devices.

The project is divided into four stages: 1) Preliminary Design; 2) Design; 3) Implementation and Development; and, 4) Field Testing.

Results—The HMMC Interface Unit (IU) is a microprocessor-based system which, when interfaced with the Icon through the external keyboard port and serial port, emulates the keyboard and trackball functions. The IU translates inputs from alternative keyboards into Icon compatible keycodes or keycode strings. Default keyboard translation tables are stored on the Icon's hard disk (Lexicon) and are downloaded to the Icon. Teachers can create individualized keyboard layouts which are stored as configuration files for specific students. A configuration file can consist of one to one (letter to letter) mapping or one to many mappings. In a one to many mapping, a key pressed on the alternate keyboard transmits a preprogrammed message or command to the Icon. This method of transmission permits transparent access to the Icon which means that physically disabled students can use the software on the Icon system.

The current IU is hard-wired to the Icon and alternate input devices are plugged into the IU. Development of an infra-red linked remote IU is continuing. In this remote version, a transceiver unit connected to the Icon will communicate with an input unit mounted on a person's wheelchair.

The software that controls the creation and downloading of keyboard layouts and key (re)definitions has been completed and was tested during the current stage (2) of the project. In addition to this software, the user interface, instructions and support functions were designed during this stage.

The Interface Unit was evaluated with a number of commonly used alternative keyboards. Alternative devices evaluated were: a) *keyguard:* a plexiglass keyboard overlay with holes over the keys to assist in targeting individual keys and designed for the Icon keyboard; b) *extended trackball:* a trackball mounted in a separate chassis and connected to the Icon via a 2 m extension cord; c) *extended keyboards:* Serial ASCII and parallel keyboards, e.g., RCA or Apple II keyboards connected via a cable to the IU; d) *enlarged keyboards:* e.g., Unicorn and King Keyboards; e) *miniaturized keyboard:* e.g., Mini Keyboard; f) *five switches:* mechanical or capacitive switches or a four-position joystick with selector switch; and, g) *MOD keyboard:* a front-end computer system based on a VIC 20 computer developed by NRC's Biomedical Engineering Program.

A prototype version of the IU was evaluated by the clinical team. Forty-nine physically disabled students were evaluated at the Hugh MacMillan Medical Centre School. All students required some form of adaptive interface to be able to use the Icon. The results indicate that the different levels of adaptation (extended devices to alternative or emulated devices) achieved are very satisfactory.

Future Plans/Implications—The next development phase of the IU consists of the field test in which the unit and the Teacher Utility software will be evaluated in four schools in Ontario. This field evaluation will test the principles embodied in the support software and thus the feasibility of providing on-line suggestions for interfacing students to professionals (teachers and therapists) who have varying degrees of exposure to physically disabled students and/or computers.

Publications Resulting from This Research

Development of a Microcomputer-Based Keyboard Emulator for Improved Accessibility. D'Alessandro J, Gosine R, Literowich W, Verburg G, Naumann S, *Proceedings of the Ninth Annual Conference on Rehabilitation Technology (RESNA)*, 6:262-264, Minneapolis, MN, June 1986.

Towards Improved Accessiblity of the Icon Educational Microcomputer. Verburg G, Sim J, Field D, Balfour L, Bowles J, *Proceedings of the Ninth Annual Conference on Rehabilitation Technology (RESNA)*, 6:439-441, Minneapolis, MN, June 1986.

The Development and Clinical Evaluation of a Radio Frequency Linked, Computer-Based, Voice-Controlled Workstation for the High Level Quadriplegic

S. Naumann, Ph.D., P.Eng. and J. Bugaresti, M.D., F.R.C.P.(C)
Hugh MacMillan Medical Centre, Toronto, Ontario, Canada M4G 1R8

Sponsor: *The Ministry of Community and Social Services (COMSOC), Applied Program Technology Unit (APT), Government of Ontario, Canada*

Purpose—This study had the following objectives: 1) to evaluate three commercially available voice recognition cards for IBM PC-XT compatible computers; 2) to test voice recognition input to the computer via a radio frequency link; 3) to integrate environmental control features such as telephone management, light and appliance control, and infrared transmission into the voice-controlled workstation; and, 4) to evaluate, with C4, C5 and C6 quadriplegic subjects, the effectiveness of voice recognition as an input method to a computer-based workstation.

Progress—Three commercially available voice recognition systems were purchased for IBM compatible computers and a comparative evaluation was performed on the following systems: 1) Voice Link by Voice Works (now Voice Key by Roar Technology); 2) Voice Card VPC 2000 by Votan (Votek in Canada); and 3) TI-Speech Evaluation and Development System by Texas Instruments.

A series of vocabularies was developed which were representative of the number of commands required to access the majority of workstation functions. These commands, with keystroke outputs, were established for telephone management functions, X-10 Powerhouse lamp and appliance controller, GE Control Central programmable infrared controller, DOS commands, Wordstar wordprocessing commands and general alpha-numeric transparent keyboard operation. Each voice recognition board was tested with a vocabulary containing the standard phonetic alphabet, numeric control, basic punctuation and function key control. Once the trained vocabulary had been tested for appropriate recognition accuracy levels and any problem phrases retained to optimize recognition, all phrases in the vocabulary were tested three times. The first and second choice scores indicated by the recognition board were recorded for each utterance.

Each board was also tested to determine if training and creation of vocabularies could be completely done by using only voice commands, once a basic vocabulary had been established. The ability to change vocabularies for different applications by uploading templates from disk is an important feature for a major user of voice recognition. The limitations of each board in performing these functions and computer motherboard memory consumption were noted.

Additional board functions, such as digitized and synthesized speech output, telephone management, and the ability to output multiple key control sequences were noted and used in the final determination of the particular board to be used in the workstation development.

Two methods of radio transmission were utilized to transmit voice commands from the user to a receiver interconnected with the voice recognition board. Voice-activated FM transceivers complete with headsets were tested, along with a cordless telephone set for voice transmission. Recognition

accuracy was tested and documented, using the standard vocabulary and with both transmission techniques, in front of the computer and at a fixed distance from the computer.

Hardware was developed to adapt the General Electric Control Central programmable infrared controller for voice control via the computer workstation. Voice control of lamp and appliance control modules was accomplished through a commercially available X-10 Powerhouse controller.

A survey of quadriplegics was performed to determine the features that would be important in a workstation as an aid for daily living and as a vocational tool. The results of the survey were documented.

The clinical evaluation of the system involves basic computer skills training, familiarization with voice control techniques, and the training of a skeleton set of vocabularies for workstation control. The trained vocabularies are to be tested for recognition accuracy with each subject and the performance noted. A script of tasks has been developed that each subject will follow and their performance at each task will be timed and any errors noted. Subjective user comments about the computer workstation will be solicited.

Toward Development of a Protocol for Assessing the Communicative Interaction Skills of Nonspeaking Severely Handicapped Individuals

P. Parnes, B.Sc., D.S.P.A.
Hugh MacMillan Medical Centre, Toronto, Ontario, Canada M4G 1R8

Sponsor: *Ministry of Community and Social Services through the Developmental Services for Adults (DSA) Program of the Metropolitan Toronto Association for the Mentally Retarded*

Purpose—The goal of the research project was to develop a protocol to assist trained clinicians in assessing the communicative interaction skills of non-speaking severely handicapped adults and their facilitators.

Progress—Essentially, the conceptual model of the assessment protocol involves six interrelated components: 1) Gathering background information in order to identify general questions or concerns which need to be explored in the assessment; 2) Observing and describing client interaction skills in client-facilitator interaction within naturally occurring contexts, in order to determine the communicative functions and modes of communication typically used by the client; 3) Investigating the client's skills further, in order to determine his/her potential to use additional functions or modes, which were not observed in the naturally occurring contexts; 4) Setting appropriate goals for client intervention; 5) Observing and evaluating facilitator interaction strategies in client-facilitator interaction within naturally occurring contexts in order to determine the appropriateness of the support provided for the client; and 6) Setting goals of facilitator training.

The specific steps and procedures involved in each component are described in detail, and a case study is presented to illustrate the specific application of the assessment protocol.

Publications Resulting from This Research

A Protocol for the Assessment of the Communicative Interaction Skills of Nonspeaking Severely Handicapped Adults and Their Facilitators. Light J, McNaughton D, Parnes P, 1986. Available from the Blissymbolics Communication Institute, 350 Rumsey Road, Toronto, Ontario M4G 1R8, Canada.

Toward Development of a Universal Modular Wheelchair Tray for Communication, Mobility and Activities of Daily Living (ADL)

P. Parnes, B.Sc., D.S.P.A.
Hugh MacMillan Medical Centre, Toronto, Ontario, Canada M4G 1R8

Sponsor: *National Health Research and Development Programme (Health and Welfare Canada), and The Hospital for Sick Children Foundation, Toronto*

Purpose—The objective of this study was to develop a prototype universal modular wheelchair tray which meets the therapeutic goals of the therapist and the personal needs of the user/caregiver.

Specifically, the goals of the research were: 1) to design a prototype modular wheelchair tray which can be partially tilted to various positions and be folded away beside the wheelchair by the caregiver; and, 2) to fabricate and assess the performance of the prototype modular tray.

Progress—A prototype tray was developed to address the multiplicity of features required by a tray that is used for work, play, augmentative communication, and for daily living activities. The modular tray incorporates an independent aluminum frame, shaped plastic tray modules, tilting and locking mechanisms, and a fold-away device.

The tray frame consists of U-shaped aluminum tubing joined to two inter-connected aluminum angles by single axis hinges. The upper and lower halves of the frame are designed to fold into each other to minimize the folded tray thickness. Two polyethylene sheets, cut to fit into the tray frame, are the "standard" tray modules and may be replaced with other modules, such as the HMMC Extended Vocabulary Augmentative (EVA) Communication Device. The upper and lower trays are connected along the hinge axis by a polyolefin living hinge to provide a continuous surface at any tray angle. Both tray modules are protected from soiling by thin, clear acetate covers.

The tilting and locking mechanisms are located at each side of the tray hinge. The locking action of the mechanism is created by the mating of a spring-loaded internal gear segment in the upper tray frame and an external gear fastened to the stationary lower tray frame. By actuating a brake release at each hinge, the upper half of the tray may be tilted and locked in twelve degree increments over 180 degrees from the fully opened to the fully closed position.

Three different fold-away devices were developed and fabricated. Each device was designed to allow the caregiver to store the modular tray manually at the side of the wheelchair when not in use, without detaching the tray from its wheelchair. The fold-away device features two tubular rails located beneath the tray which guide it from its normal position in front of the user to the side of the wheelchair.

Four prototype trays were fabricated, fitted, and sent out on trial during the first of three assessment phases beginning in the Fall of 1986. Technical and clinical assessment will be conducted for each tray system dispensed. Results of the assessment will be available in 1987.

Preliminary Results—Seven subjects have been fitted with modular tray prototypes. Preliminary results of caregiver and technical assessments indicate that the tilting operation was well received; however, further development of the wheelchair interfacing hardware is required. Final results of the evaluations are not yet available.

PACA—Portable Anticipatory Communication Aid

Craig W. Heckathorne, M.S.E.E.; Dudley S. Childress, Ph.D.; Lew J. Leibowitz, B.S.E.E.; Jerrilyn A. Voda, M.S., C.C.C.S.P.
Rehabilitation Engineering Program, Northwestern University, Chicago, IL 60611

Sponsor: *National Institute on Disability and Rehabilitation Research; Easter Seal Research Foundation*

Purpose—The PACA was a research and development project to design a portable computer communication aid which would enhance the communication abilities of non-vocal persons who also have

physical impairments which preclude the use of direct selection techniques. The project had two primary objectives: 1) to augment the utility of traditional scanning communication aids by adding message element anticipation; and, 2) to make this scanning communication aid cost effective to the user by capitalizing on the benefits of the innovative technology and competitive marketing of an available commercial portable computer.

Progress—The PACA communication aid has been completed and is in commercial distribution. It is available as an EEPROM-based program running on the Epson HX-20 portable computer. The program configures the Epson's features to support person-to-person (conversational) communication, note taking, writing, and math calculations. Two operational versions of the program are available: a single-switch automatic scanning version and a two-switch step-scanning version.

A major emphasis of the PACA program is the use of anticipatory (predictive) algorithms, which on the average reduce the number of scanning steps and switch activations needed to create a message. The improved efficiency of message creation can result in improved rate of message generation for persons with severe motoric involvement.

The PACA program has been made commercially available through a licensing agreement between Northwestern University and Zygo Industries, Inc. (Portland, Oregon), a manufacturer of electronic communication systems.

Available Motions of Hand, Mouth, and Head Stick Users: Applications to Keyboard Designs

Everett Johnson; Ray Smith; Georgios Yiallovros; Adisak Mekkittikul
Rehabilitation Engineering Center, Cerebral Palsy Research Foundation of Kansas, Inc., Wichita, KS 67208
Sponsor: *National Institute on Disability and Rehabilitation Research*

Purpose—The purpose of this project is to develop techniques for measuring head and neck motion; to provide a measurement system and head-motion data to support basic research in head motions; and using the information obtained, to develop keyboards for use by persons restricted to activating keys with head, hand, or mouth sticks.

The advent of the personal computer (PC) has provided the severely handicapped person with the means of communicating, controlling the environment, and even gainful employment. The category of handicapped persons this project addresses are those who, as the result of neurological impairment, cannot use a standard keyboard in the way it was designed. Persons with this type of handicap are restricted to activating the keyboard one key at a time, with a single digit, i.e., finger, hand stick, mouth stick, or head stick. Various techniques, such as the use of positioning templates, have been designed to improve the handicapped person's use of a standard keyboard. Persons forced to use a head stick are the primary target of this effort.

Progress—The methodology involves the determination of motion capabilities of the handicapped population. Efforts were directed toward determination of the range of motion of the neck and head. The range of motion of the tip of a head stick is a function of its length and the range of motion of the head and neck to which it is attached. Head motion measurements have been taken on able-bodied and handicapped persons. These data have been used to support the keyboard design activity and to provide useful information for fundamental head-motion research. The kinematic model considered here consists of three angular motions: flexion or extension in the sagittal plane, lateral bending in the frontal plane, and the rotation of the transverse plane.

From data related to head motion, it was determined that the ideal keyboard configuration would require the ability to make motions in two dimensions only. The keyboard is called a Two-Degrees-of-Freedom (2DOF) keyboard. The head stick penetrates the vertical keyboard surface in which there are horizontal paths, or key channels, along which keys are located. The user can use the lower part of each horizontal path as a support for the head stick while the next key is sought. The keyboard is transparent to the computer; that is, it can be used

to access any software available to an able bodied user, without requiring modification of the computer.

As a first step, a computer program was written that simulates a single key set of the 2DOF keyboard. The output of the program gives the total distance traveled between keys and the total number of key hits required to type a sample text in English. The distance is measured in normalized units, (normalized with respect to the space between keys). In calculating the number of key hits, only the key hits that initialize each key are considered.

In testing the relative merits of different key combinations, a 4,000 word sample was used as input to a simulation program. For choosing the best key arrangement among those that were promising, a 10,000 word sample was used. The 10,000 word sample was chosen from several sources such as newspapers, magazines, etc.

One of the advantages of the 2DOF keyboard is that each one of its 90 keys can represent up to 16 characters in the form of single words, small phrases, and so on. This feature of the 2DOF keyboard was used to minimize the number of key hits required, by assigning frequently used groups of letters to as many keys as possible. With groups of letters represented by a single key, a word or a small phrase can be typed by using as few as one or two key hits. Every combination of bigrams, trigrams, and single letters that was thought would decrease the number of key hits was tested, and the more efficient combinations were examined more thoroughly.

Four key sets have been selected for implementation on a pre-production prototype keyboard; general text input, single-key-initiated "WordStar" commands, special characters, and phrases frequently used that can be programmed for an individual user. (The latter keyboard set can be used as a communicator as well as for computer input. Each key selected allows displaying up to 16 characters. Typical phases or words assigned to the keys of key set four are: HELLO, GOOD MORNING, MY NAME IS, WHAT DO YOU MEAN, TAKE ME HOME, or TO THE BATHROOM.)

Results—A 2DOF keyboard appears to be a significant improvement for specialized handicapped user applications. A pre-production model has been fabricated and is currently being operated experimentally.

Future Plans—The development of a production model of the keyboard, documentation, and further study of key placement is proposed for the immediate future.

International Compatibility Standards for Electronic Communication and Interface Devices

Joseph M. Schauer, B.S.; Barry L. Rodgers, B.S.; David P. Kelso, M.S.; Charles C. Lee, M.S.; Gregg C. Vanderheiden, Ph.D.
Trace Research and Development Center, Waisman Center on Mental Retardation and Human Development, Madison, WI 53705

Sponsor: *National Institute on Disability and Rehabilitation Research*

Purpose—A set of projects has been underway to develop compatibility standards for electronic communication systems and user-interface devices. Providing compatibility between devices from different manufacturers increases the ability of persons with disabilities to use appropriate aid systems, and makes it easier for educators and clinicians to evaluate, prescribe, and apply equipment and software from different manufacturers.

Progress—The Trace Center has been involved in: 1) developing compatibility standards; 2) working with manufacturers to implement compatibility standards; and 3) supporting national and international standards organizations considering the standards or developing adaptations for international use. These proposed standards are developed with continual feedback from interested manufacturers, clinicians, researchers, and users in North America, Europe and Australia. Proposals have been written to establish standards for Simple Electrical Transducers and Serial Code, Keyboard Emulating Inter-

faces, Morse Code and Input Selection Arrays. Proposals for Serial Interface Control for Powered Wheelchairs, and Infrared Environmental Controls, are under development.

Publications Resulting from This Research

Keyboard Emulating Interface Compatibility Standard Proposal 4.0 Version 1. Rodgers BL, Schauer J, 1986.

Computer Accessibility: Support of the Industry/Government Initiative

Gregg C. Vanderheiden, Ph.D.; Charles C. Lee, M.S.; David P. Kelso, M.S.
Trace Research and Development Center, Waisman Center on Mental Retardation and Human Development, Madison, WI 53705

Sponsor: *National Institute on Disability and Rehabilitation Research*

Purpose—This project supports the efforts of the Industry/Government Initiative which brings together computer manufacturers, developers, and consumers in order to give disabled individuals better access to standard computer hardware and software systems.

Progress—The project was started in 1984 to support work by the White House, the Office of Special Education and Rehabilitation Services (OSERS), and the National Institute on Disability and Rehabilitation Research (NIDRR). A committee of computer manufacturers, including Apple, AT&T, Digital Equipment Corp., Hewlett Packard, Honeywell, IBM, and Tandy (Radio Shack), as well as representatives from government agencies, research groups, rehabilitation manufacturers, and disabled individuals, have been involved in the project.

In 1985, a "white paper" was completed at the request of the computer industry. This paper carefully discussed the problems faced by persons with disabilities, examples of solutions, and the difficulties with implementing various strategies. A videotape illustrating state-of-the-art computer accessibility was produced that included clips from computer access centers around the country.

In 1986, several versions of a document outlining "Considerations in the Design of Computers" (formerly "Guidelines") were completed. This document, which reflected the combined input of industry, researchers, and consumers, provided a revised summary of the problems, populations affected, the priorities, and possible solution strategies.

In 1987, members of the Task Force provided input to the National Institute on Disability and Rehabilitation Research (NIDRR) and General Service Administration (GSA) during the development of procurement guidelines to increase the accessibility of electronic office equipment. The Task Force contributed ideas and expertise from its earlier work and provided specific review of NIDRR and GSA proposed guidelines.

Results—This project has resulted in facilitating the computer industry in their consideration of design and manufacturing of products to optimize the access of computers to persons with disabilities by highlighting need and suggesting economical and feasible design ideas.

Publications Resulting from This Research

Computer Accessibility Considerations. Vanderheiden GC, Lee CC, Scadden LA, *Proceedings 10th Annual RESNA Conference,* 7:750-752, San Jose, CA, June 1987.

Advance Executive Summary of the Considerations Document Version 2.0. Vanderheiden GC, Lee CC, 1987.

Considerations in the Design of Computers and Information Processing Systems to Increase Their Access by Persons with Disabilities Version 2.0. Vanderheiden, GC, Lee CC, April, 1986.

White Paper: Access to Standard Computers, Software, and Information Systems by Persons with Disabilities Version 2.0. Vanderheiden GC, 1985 Revision.

Computer Access for Disabled Individuals. (VHS Videotape). Brandenburg S (Script Writer & Ed.), 1985.

ALTKEY: A Multi-Mode Input Program for the IBM-PC

Lincoln A. Jaros, B.S., and Simon P. Levine, Ph.D.
Rehabilitation Engineering Program, Department of Physical Medicine and Rehabilitation, University of Michigan Medical Center, Ann Arbor, MI 48109

Sponsor: *Rehabilitation Engineering Program, Department of Physical Medicine and Rehabilitation, University of Michigan*

Purpose—Many handicapped users have special problems which must be solved in order to give them access to the full power of a computer. Many types of disabilities prevent a user from effectively controlling the computer through the standard keyboard. These users must be able to use one or two special switches to reproduce the wide variety of keystrokes available on the keyboard and/or develop means for increasing input rates. The IBM-PC and PC-compatible computers have established themselves as the standard personal computers in business and industry, which together with their capabilities and steadily decreasing costs, have made them an excellent choice for handicapped users. The purpose of this research project is to develop a comprehensive programmable input system for the IBM-PC which can function in a wide range of modes (e.g., scanning, coding, Morse code, etc.).

Previous work has included basic development of ALTKEY, a memory-resident computer program for the IBM-PC, designed to fulfill these objectives. ALTKEY augments the device driver software already present in the basic input/output system read only memory (BIOS ROM). Input generated by this system goes to the regular keyboard buffer where it is treated as actual keyboard data. The first mode developed was a scanning system, allowing each user to design and edit individualized scan menus. In the scanning mode, the user is presented with a series of input choices listed across one line of the video screen. These choices are highlighted one at a time in a repeating pattern. The user makes a specific choice by activating a single switch when the desired entry is highlighted. The switch can be one of the shift keys on the keyboard or a momentary switch connected to a game port input. Each selection can display a new set of choices or send key codes to the keyboard or both. The list of branching menus and entries is called a Scan Tree. The Scan Tree is defined in a simple text file called a Scan Tree Definition File. The user can create and edit these files, customizing them for specific application programs. The flexibility of the tree design allows required selections to be minimized by presenting the user with the most likely choices first.

Progress—Morse code capabilities have been added to ALTKEY. At any point in the Scan Tree described above ALTKEY can be programmed to shift into a Morse code entry system. For an experienced user, this can increase the speed of general text entry significantly. Combining the two data entry modes allows complex or lengthy keyboard sequences to be generated with a Scan Tree, while random text entry can be expedited with Morse code.

Another new feature of the program is the Hold Item. The Scan Tree can be programmed so that holding the selection key down for a set period of time activates some action. This feature is always active (in both scanning and Morse code modes) so that it can be used to prevent the user from becoming stuck in some unexpected loop. When this happens the user can re-boot the computer by holding down the selection key for five seconds (or any other predefined time period).

Future Plans/Implications—ALTKEY currently has only one type of scanning scheme. This single-switch protocol is explained above. In the future, the program may be expanded to allow the use of two, three, or four switches for schemes that would afford some users greater speed. For example, one switch could be used to advance the highlighted scan item while a second switch could be used to make a selection. By using four switches it would also be possible for a user to make a direct selection from a scan menu of four items.

Publications Resulting from This Research

A Single Switch Keyboard Emulator for the IBM-PC. Jaros LA, Levine SP, *Proceedings of the 8th Annual Conference, IEEE Engineering in Medicine and Biology Society,* 1823-1825, 1986.

ALTKEY: A Special Input Program for the IBM-PC. Jaros LA, Levine SP, *Proceedings of the 10th Annual RESNA Conference,* 7:714-716, San Jose, CA, June 1987.

Assessment and Prescription of Writing Aids for Physically Handicapped Children

S. Jarvis, B.Sc.(P.T.) and R. Lanno, B.A.
Hugh MacMillan Medical Centre, Toronto, Ontario, Canada M4G 1R8

Sponsor: *Research Department, Hugh MacMillan Medical Centre*

Purpose—This study proposes to prescribe writing aids for a small number of students with difficulties in writing skills: to provide these students with training in the use of these aids and to assess the efficacy of the prescription.

Progress—Five Ontario school students, from our out-patient population, are included in this study. Each student has a basic language capability to read and understand print. However, these students have difficulty producing acceptable written work in school. The students were administered the following tests: 1) Stanford Diagnostic Reading Assessment (SDRA) Test Form A (Levels Red and Green) to check functional reading levels; 2) Bruininks-Oseretsky Test of Motor Proficiency (Bruininks, 1978); and 3) North York Self Concept Scale, primary level (Crawford, 1977; Cassidy, 1974; Cassidy and Brooks, 1978).

In addition, the students performed the following writing tasks: 1) Name, address, telephone number, age, school; 2) Copy from text (timed for 5 minutes); 3) Spelling (at grade level); and 4) Sample of classroom written work (obtained from teacher).

The student, teacher, and parent(s) were interviewed. Students were assessed and prescribed a suitable writing aid (computer with printer) and word processing software program. Commodore 64, the word processing program Bank Street Writer, was used. All but one of the students and teachers received training in the use of the writing aid at school until the student reached an independent capability. The remaining student and mother received training at home. Up to twelve sessions of 45 minutes duration were given.

The students then used the writing aid for approximately four months. The occupational therapist provided Student/Teacher support in bimonthly visits to the school or the home during this time.

Preliminary Results—All but one of the students were able to independently access the computer. At the end of the trial period (4-5 months), the initial assessments were repeated. The writing tasks have yet to be completed and will be performed with the computer. Non-parametric t-test (Walsh test) of pre- and post-measure for the SDRA, Bruininks, North York Self Group and the writing tests will be performed. Information has been requested of the teachers and parents concerning the use the child has made of the computer.

Future Plans/Implications—All but one of the children in this project attended a school for the physically handicapped. Further research should assess the needs of writing aids for children with writing problems attending the public school system. The question of whether computers or electronic typewriters best suit this type of child, and the environment in which they function, remains to be investigated.

Evaluating the Effectiveness of Direct Client Intervention and Facilitator Training in Communication Intervention with Nonspeaking Physically Disabled Children: Pilot Study

P. Parnes, B.Sc., D.S.P.A.
Hugh MacMillan Medical Centre, Toronto, Ontario, Canada M4G 1R8

Sponsor: *Research Department, Hugh MacMillan Medical Centre*

Purpose—The goal of the pilot research project was to evaluate, through successive implementation, the effectiveness of a two-phase intervention program on the communicative interaction of a nonspeaking physically disabled child and his primary facilitator. The intervention program involved direct service

intervention with a nonspeaking child; and then, training for his primary facilitator.

Progress—The research project was a pilot study and involved a single dyad. The child was a four-year-ten-month-old boy with a diagnosis of cerebral palsy with severe spastic quadriparesis. The primary facilitator was the child's mother. The study involved the following stages: baseline prior to intervention with the child; and the addition of facilitator training on a group and individual basis. The first phase of the study involved direct intervention with the child during two half-day sessions over a two-week period. Issues addressed during direct intervention witn the child were as follows: the introduction of adaptive toys operated by a single switch; the introduction of an initial augmentative communication system (i.e., a portable picture communication display); the development of appropriate means to access the display; the development of strategies to request attention, to request assistance, to request information and to initiate topics; and the provision of consistent feedback to confirm or reject the partner's interpretation of messages.

The second phase of the study involved intervention directed toward the child's mother on an individual and small group basis. Individual facilitator training occurred during two half-day sessions over a two-week period. The sessions involved informal discussions and modeling of the following interaction strategies: providing choices to the child; responding to the child's lead; pausing; developing interaction on novel topics; asking appropriate questions; and modeling the use of the child's augmentative communication systems. In addition to the individual sessions, the mother also attended a one-day workshop on Establishing Basic Communication Skills offered by the Augmentative Communication Service (ACS). The workshop involved approximately ten participants in group discussion and problem-solving related to issues in facilitating communicative interaction with non-speaking individuals.

The child and his mother were videotaped for a ten-minute period in an unstructured free play situation on three separate occasions: 1) baseline; 2) following intervention with the child; and 3) following facilitator training. The videotaped interactions were transcribed and coded through a detailed system of analysis developed by Light (1985). In summary, the interaction was analyzed with respect to the following three variables: 1) the discourse status of the turn; 2) the communicative function; and 3) the mode of communication. Data were analyzed for mother and child variables across each of the three stages of intervention to determine the cumulative effects of the program.

Results—Results of the study indicated that the intervention program affected the child's modes of communication, his communicative functions and his discourse status. In general, the child assumed a more active role in the interactions following intervention: he initiated more topics, made more requests for objects and activities, and issued more feedback responses to confirm or deny his mother's interpretations of his messages. The intelligibility of the child's communicative turns increased over the two-phase intervention program, as did his use of his communication board and his use of gestures as a means to augment his communication.

The two-phase intervention program also significantly affected the mother's modes of communication, her communicative functions and her discourse status. Following intervention, the mother provided more models of communication board use for the child. She seemed less concerned with directing her child's behavior and more concerned with encouraging his active participation in the interaction. In general, the mother showed increased responsiveness to her child following intervention.

The greatest changes in the mother's interaction patterns were effected at stage three following facilitator training on a small group and individual basis. Changes in the child's interaction patterns, however, were effected successively across stages two and three. While the direct client intervention (stage two) served to enhance the child's interaction strategies, the facilitator training (stage three) and the resulting changes in his mother's interaction strategies allowed him increased opportunities for communication within the interaction.

Publications Resulting from This Research

The Effect of Communication Intervention with Nonspeaking Physically Disabled Children. Light J, Rothschild N, Parnes P. Paper presented at *The American Speech Language and Hearing Association Annual Convention,* Washington DC, 1985.

COGORTH: Cognition Orthosis Programming Language

Lincoln A. Jaros, B.S.; Simon P. Levine, Ph.D.; Ned L. Kirsch, Ph.D.
Rehabilitation Engineering Program, Department of Physical Medicine and Rehabilitation, University of Michigan Medical Center, Ann Arbor, MI 48109

Sponsor: *Robert Wood Johnson Foundation, Princeton, NJ*

Purpose—Patients who acquire diffuse and/or focal lesions of the brain often sustain dramatic and potentially debilitating changes of cognitive functioning. A technique for assisting such patients to function independently using a computerized cognition orthosis has been developed. It has been successfully used to guide brain-injured patients through tasks which they could not otherwise perform unaided (see "Computerized Task Guidance for Cognitively Impaired People," elsewhere in this issue).

This report describes some of the features of the programming language called COGORTH (from COGnition ORTHosis), specifically designed for the development of computerized cognition orthoses.

Progress—COGORTH is a specialized computer language providing a highly structured environment for providing cues and programming sequential messages. These cues and messages can be used to assist patients who need guidance for the completion of complex activities. Current capabilities permit message presentation on a video display and the use of audio or visual cues such as computer-generated musical tunes or flashing room lights. A COGORTH program (called an Instructional Module) can display directions to a patient and then make decisions about future actions based on the patient's response.

COGORTH provides Instructional Module programming capabilities which can: a) check a patient's performance for errors and time compliance; b) branch to error correction or extended help procedures when necessary; c) provide guidance for multiple concurrent tasks; d) allow a task with higher priority to interrupt less important tasks; e) control electrical devices in a patient's environment.

Instructional Modules are simple text files which may be created and updated with any text editor. Although COGORTH is an interpreter, it permits the use of library files for the inclusion of user-defined functions and routines. It is envisioned that COGORTH will be used by health professionals having a wide range of programming skills. Careful consideration has been given to balance the power and complexity of the language with the need for simplicity.

Preliminary Results—The original version of COGORTH was written in C and implemented on the Apple II. Two years ago, it was ported to the IBM-PC and has since undergone significant enhancement. Recent additions allow the language to handle much larger IMs (Instructional Modules) with greater speed. Several important changes to the control structure have been incorporated. These include an "ELSE" option for "IF" statements and parameter passing in subroutine calls. The programmer now has the choice of displaying messages using large graphics characters appropriate for visually impaired patients. The language can use either of two commercially available environmental control units to turn lamps and appliances on and off. It can now also play musical tunes using the system speaker as opposed to just producing simple monotones.

Future Plans/Implications—The evolution of the COGORTH language is an ongoing process. The motivating force behind this change is the continuing computerized task guidance research for which it was designed. Additions in the near future will be: improved automatic storage of performance measures recorded for later analysis and synthesized voice output for audio presentation of messages. Longer range plans call for adding a user-friendly front end to the program. This front end would be designed to help a new programmer to easily understand and use COGORTH language features.

Publications Resulting from This Research

COGORTH: Cognition Orthosis Programming Language. Levine SP, Kirsch NL, Jaros LA, *Proceedings of the 7th Annual Conference, IEEE Engineering in Medicine and Biology Society*, 700-702, 1985.

COGORTH: A Programming Language for Computerized Cognition Orthoses. Jaros LA, Levine SP, Kirsch NL, *Proceedings of the 8th Annual RESNA Conference*, 5:359-360, Memphis, TN, 1985.

Application of Technology to Enhance the Employability of Severely Communicatively Impaired Individuals

Elizabeth J. Allen, Ph.D. and Andrew Y.J. Szeto, Ph.D.
Assistive Device Assessment Program, Clinical Training Center, San Diego State University, San Diego, CA 92182

Sponsor: *U.S. Department of Education—Office of Special Education and Rehabilitation Services*

Purpose—Employment for persons with severe disabilities is often an unfulfilled dream. One of the major barriers to successful employment for this population is adequate communication for the workplace. Although computer technology has augmented the potential communication skills of the person with physical disabilities, little attention has been given to resolving communication problems related to entering and retaining employment. Therefore, the purpose of this demonstration project has been to develop a multidisciplinary approach for analyzing the communication needs of a client in a particular workplace; for prescribing and customizing an appropriate communication system for that client; and for training that client to have communication competence for the workplace. The removal of the communication barrier to employment would provide greater independence as well as economic and psychosocial benefits for the person with disabilities.

Progress—An important feature of this project has been the development of rapid, targeted, assessment procedures. Utilizing this approach, it has been possible to identify the type of augmentative communication device needed by a client after two or three 2-hour visits to the Clinical Training Center on the San Diego State University Campus.

The targeted assessment procedures begin with a comprehensive preassessment evaluation conducted by the multidisciplinary Assistive Device Assessment Program (ADAP) team. The critical elements of this evaluation are a screening interview with the referring individual, a detailed application form, and written reports from the potential client's physician and other agencies providing professional services. Based on this information, the ADAP team decides whether to accept the client and, if so, what additional information is needed. The team social worker then gathers the needed information through additional collateral contacts, one or more home visits, and (if relevant) visits to the client's school or sheltered workshop.

The application materials and the social-work report enable the speech and language pathologists on the team to plan a cognitive/communication assessment that utilizes parts of various standardized tests as well as a variety of informal measures specially chosen for the particular client being assessed. This assessment constitutes the first of the two on-campus evaluations.

The results from the cognitive assessment are used to guide subsequent evaluations of the client's physical/technical skills and vocational potential. The physical/technical assessment procedures encompass gross and fine motor skills, the client's ability to operate keyboards and switches, and the best anatomical control site in terms of accuracy and speed. Following this assessment by the team rehabilitation engineer, the client is evaluated using communication devices (either directly or through simulation) to determine which devices are suitable for the client.

The Vocational Placement Phase has been the most difficult aspect of the demonstration project for three main reasons: 1) the clients referred to and accepted into the project have not been considered as having any vocational potential because of their severe disabilities; 2) funding for communication devices is limited or unavailable for most project clients; and, 3) there are few employment sites open for clients with severe physical and communication disabilities.

Not only have many project clients not been vocational rehabilitation clients, they also have not even been in vocational preparation programs. Therefore, considerable effort has been expended to prepare clients for employment. Although third-party funding of communication devices has always been problematic, funding of devices for individuals who acquired head injuries after age 18 is particularly difficult, since these clients often are eligible for only acute-care services. Even when a client does acquire a communication device and has been prepared for partial employment, the client may not have an opportunity to work. In addition to the usual employer apprehensions about disabled employees, many employers are not aware of recent

technological developments that can facilitate work performance or communication. Consequently, these employers do not consider hiring individuals with severe disabilities.

Progress—The project team developed several approaches to overcome some of these difficulties. They include the following:

1) Training clients to use the recommended device on a regular basis in order to document the appropriateness of the device for communication and employment.

2) Working with representatives of various community agencies to develop their awareness of a client's vocational potential, when given an effective method of communicating at the worksite.

3) Developing new routes to the workplace for clients. Some of the more promising avenues include placement in sheltered workshops, individualized vocational training programs, and supported work. Each of these approaches has required considerable investment in time and energy from the ADAP team and various community agencies.

All of the accepted clients have completed their cognitive and physical/technical assessments for using a communication device. Currently, six project clients are undergoing some type of training for improving their communication competence and/or vocational potential. Two of these clients have secured and are actively using an appropriate electronic communication system, and 13 clients are being processed for device funding. Seven clients are in the vocational phase of the project, with three being processed by Vocational Rehabilitation and four placed into a suitable vocational situation.

Although Federal funding for this project ended in September 1987, clients who have not yet acquired a communication device or are still in the vocational phase will continue to receive project support through the clinical practicum associated with the Assistive Device Assessment Program.

Results—In spite of the difficulties encountered, the demonstration project has been very worthwhile in several respects. The project provides a much needed community service, one that is unavailable elsewhere in the area. Another benefit is the active involvement of graduate students on an interdisciplinary team. This practical clinical experience has expanded their problem-solving skills. Third, the project has demonstrated that a complex process can be achieved through targeting assessment procedures. In addition, the project's efficient assessment procedures have been successfully used to support the procurement of much needed communication devices for several of the clients. Lastly, the project has clarified several important issues that affect employability enhancement through technical communication devices and the translation of that enhancement into vocational rehabilitation of severely communicatively impaired individuals.

While the demonstration project has benefited clients and the ADAP team members, it also identified two major problems: 1) members of vocational rehabilitation agencies and employers have a very limited awareness of technological applications to enhance communication and employability; and 2) the processes of acquiring communication devices, training device competency for employment, and developing work skills are very time consuming (often a year or more in length) and require an extensive network of resources. Resolution of these problems involves more public education, increased funding for communication devices, reduced eligibility requirements for client populations, and more rehabilitation programs that focus on the client with severe disabilities.

A Model for the Assessment of the Written Communication of Nonspeaking Physically Disabled Individuals Who Use Microcomputers

S. Kelford, B.Sc. and S. Thurston, B.Math.
Hugh MacMillan Medical Centre, Toronto, Ontario, Canada M4G 1R8

Sponsor: *University of Toronto, Speech Pathology Alumni Association; Research Department, Hugh MacMillan Medical Centre*

Purpose—The objective of this research study was to develop a model to systematically describe the process of written communication by nonspeaking physically disabled individuals who use computers.

Specifically, the goals of the research were: 1) to systematically describe the form, content, and use of written communication by a small number of nonspeaking physically disabled individuals who use microcomputers; and, 2) to determine the principles and guidelines necessary to objectively assess the process of written communication by this population.

Progress—Ten subjects and their facilitators participated in the study. The subjects were divided into two groups: Group A were 8 to 10 years of age and used Blissymbols as their written communication system; Group B were 14 to 23 years of age and used traditional orthography in their written output. All of the subjects were congenitally physically disabled; had sufficient cognitive ability to permit written communication; had receptive language skills functional for daily needs; had hearing and vision (or corrected vision) within normal limits; used an augmentative system for face-to-face communication and a microcomputer for written communication in the home.

Spontaneous written output completed in the home over a 28-day period was collected from each subject. For each written sample, information regarding the intended purpose and audience, the subject matter, the amount and nature of any help provided, the length of time invested and the relative quality of the written output was obtained from the facilitator and/or subject. Each individual's writing was then described according to a coding system designed to determine the function, form, and content.

Results—Results indicated that the subjects spent a considerable amount of time writing. They composed the majority of their productions independently, and wrote for a variety of different purposes and intended audiences. The subjects demonstrated considerable facility in the form and content of their written productions. There was considerable variation across subjects within each group, as well as considerable intra-individual variation day to day.

Development of a Toy Control Program for the Apple IIe

Rob E. Garrett, B.Tech.
Rehabilitation Engineering Department, Regency Park Centre for Young Disabled, Kilkenny, S.A. 5009 Australia

Sponsor: *None Listed*

Purpose—Young children with disabilities need an appropriate reward to encourage them to develop switch access skills. A single switch is connected to the Apple IIe games port and the Apple output is used to turn a toy on or off. The Apple Toy Control Program enables a therapist to select an input switch protocol suitable for the child. Current modes are: press on/press off, press more than N times, press N times, hold for more than T seconds and hold and release after T seconds. Successful completion of the task causes the toy to run for a pre-set time.

Progress—The current version of the program is currently being tested within Regency Park Centre for Young Disabled and a printed circuit board is being developed so that production costs will be low.

Preliminary Results—Children tested so far show high motivation to develop the required switch access skills.

Future Plans/Implications—This program, along with interface hardware and a user manual, will be available from Regency Park Centre for Young Disabled by January 1988.

D. Private/Public Programs

Development of the Occupational Therapy Comprehensive Functional Assessment (OTCFA)

Roger O. Smith, MOT, OTR; Ken Ottenbacher, Ph.D., OTR; Roann Barris, Ed.D., OTR
Trace Research and Development Center, Madison, WI 53705

Sponsor: *American Occupational Therapy Foundation*

Purpose—In early 1970, the American Occupational Therapy Association acknowledged the significant inconsistency and splintered approach of assessment in occupational therapy. At that time it began sponsoring research to evaluate the significance of the problem and implement some strategies for assuring a better continuity of evaluation between service delivery settings and instituting a more comprehensive approach for evaluating the efficacy of therapeutic intervention. The most recent step in the development of a better comprehensive performance evaluation has been the formulation of the constructs and content in the Occupational Therapy Comprehensive Functional Assessment (OTCFA).

Progress—Within the past year, the project has refined the constructs and content for the assessment. Occupational therapists throughout the country, representing all the service delivery areas of occupational therapy, have been intimately involved in providing discussion and feedback to the project team. Consequently, the early phases of the OTCFA development have been extremely iterative with multiple revisions of the OTCFA instrument. The belief has been that without a solid construct and content foundation, application would be extremely limited.

Preliminary Results—The overall conceptualization is a hierarchical model of functional performance. This model is unique in that it integrates 1) high level activity functions such as basic self care activities, home making activities, vocational and avocational, with 2) the integrated skills which are necessary to adequately perform the activities, with 3) the component abilities which provide the basic elements to achieve the skills necessary to perform the activities. In this conceptual model of functional assessment, not only is it able to highlight a specific activity with which an individual is having problems, but also what sets of skills are major contributors to the difficulties in activities. The environment is viewed as a second dimension as opposed to simple categories within the performance areas, because all social, cultural, and physical environmental factors do not stand alone, but directly affect performance on all levels.

Future Plans/Implications—The full scale OTCFA includes five levels, fourteen major areas, and 117 detailed categories of function. The implications of OTCFA are many including the comprehensive assessment strategy of patients which occupational therapist treat, a documentation scheme for medical records, a technique for converting functional assessment data into treatment planning information, a framework for education curricula, and an organizational scheme for research in the field.

The OTCFA project team is currently piloting the instrument. It is anticipated that the nationwide pilot studies' subsequent revision of the instrument, development of instructional and administrative materials, and identification of test/retest and interrater reliability, will be completed in 1988. Computerization of this instrument to increase its utilization is in the planning stages.

Improving Management of Vocational Rehabilitation Services

Joseph B. Moriarty; Don E. McLaughlin; Ranjit K. Majumder; David A. Molinaro
West Virginia Rehabilitation Research and Training Center, West Virginia University, Morgantown, WV 26506

Sponsor: *National Institute on Disability and Rehabilitation Research*

Purpose—In recent years NIDRR's interest in and emphasis on improving vocational rehabilitation (VR) management has resulted in the West Virginia Rehabilitation Research and Training Center (WVRRTC) focusing its efforts primarily in that area. The Center's goals are to: a) study management theories, principles, techniques, and models; b) adapt those established entities to VR management where profitable; c) research and develop new approaches where needed; and, d) devise management procedures which are tailored to the unique needs of the VR program, and capitalize on the use of information technology to support and facilitate the management practice. Studies have been designed as 12 research projects, 5 training (utilization/dissemination) projects, and 6 special initiatives or ancillary activities.

Progress—Three research projects are currently underway to analyze decision behavior and to provide decision support in the VR setting. Client decisions are being studied in the context of vocational goals and economic future (R-1). Counselor decision making processes are being studied from the point of view of information needed and the use of technology to access and display information to facilitate decision making (R-2). Investigation of agency managers' decision processes focuses on databases of program statistics, program evaluation, and program performance.

In order to develop an integrated decision support system with information files, information processing, and information display relevant to VR management, the Center has postulated a contextual framework: what kinds of clients, with what kinds of characteristics, in what environment, receive what kinds of services, at what cost, leading to what outcomes? Five interrelated projects are in process to accomplish the goal of designing a comprehensive decision support system.

Finally, planning, both short and long range, plays a critical role in management. This process of targeting efforts and the means of achieving them is the focus of three of the Center's current projects on improving management.

Results—Project R-1 is nearly complete. Intensive structured interviews with VR clients were conducted and the resulting data compiled, organized, and validated. All that remains to be done is the preparation of reports showing the correspondence between micro-economic theory of utility and VR client responses to economic decisions, and reports indicating the application of client decision making to VR program and practice. For the R-2 project most of the necessary computer software, consisting of 12 separate components, has been developed and is either being field-tested or being revised as a result of previous testing. Current plans are for a few new programs and the implementation and evaluation of the total counselor information support package. Project R-3 necessitated the development and distribution of a survey questionnaire to obtain a comprehensive picture of the present management practices of VR agencies.

Future Plans/Implications—Plans call for an intensive analysis, a synthesis of management theory and practice, and information to the agencies. To carry out Projects R-5 through R-9, WVRRTC developed a comprehensive survey questionnaire which was distributed to 5,400 managers in VR at the different levels of hierarchy. In addition, in an accomplishment unique in VR research, four separate databases from the Ohio VR agency were merged. Tabulation and analysis of the resulting data has been completed. The production of a summary technical manual, the development of a computer program allowing managers to interactively examine combinations of factors as they contribute the key outcomes, and the national dissemination of the decision-support system prototype are all in the plans for the coming months.

Projects concerned with planning have involved: a) mathematical modeling of rehabilitation indicators over time; b) establishing relationships between the superstructure, infrastructure, and performance of VR programs; and, c) models of selection, skill development, and effective deployment of personnel.

Progress Report for the PEER Regional Network

Robert J. Rosati, Ph.D.
Human Resources Center, Albertson, NY 11507

Sponsor: *National Institute on Disability and Rehabilitation Research*

Purpose—The PEER Regional Network is designed to promote the use of proven, effective programs and practices among educators and rehabilitation professionals. The project is a resource for any individual or organization providing services in Rehabilitation Services Administration Region II (New York, New Jersey, Puerto Rico and the Virgin islands). Using a specific, uniform evaluation, the PEER Regional Network validates selected programs, formally recognizes those that are exemplary and provides technical assistance to organizations seeking to replicate exemplary program models.

The current focus of the PEER Regional Network is on programs that provide either transition or supported employment services to youth with disabilities. Special efforts are being made to validate and formally recognize programs that are serving individuals with learning disabilities and those that are in least restrictive environments.

Progress—During the first year of the project, efforts focused on developing a system which would identify exemplary programs and practices on the basis of documented outcomes. As part of this process, an advisory board of State Directors, Advocates, Researchers and Trainers was recruited to give direction to the project and eventually participate in the selection of exemplary programs.

After an extensive review of the literature and input from the advisory board, a detailed program validation questionnaire was developed. The project is in the process of validating approximately 14 transition programs. By September of 1987, data from these programs was forwarded to the PEER advisory board. Upon selection of the exemplary programs, site visits will occur to further document program components.

Preliminary Results—A major component of this project is the dissemination of information. Dissemination involves informing those in the field of the purpose of the PEER Regional Network as well as highlighting programs identified as exemplary. During the first year, the major focus was on disseminating information about the project. This was accomplished through the development of a brochure and other print materials.

Future Plans/Implications—Following the identification of exemplary programs, the project will enter its technical assistance phase. The project will encourage exemplary programs to provide technical assistance, with the support of the PEER Regional Network, to other programs interested in adopting innovative service delivery components. This technical assistance should help to improve the adopter program.

One of the most significant features of the PEER Regional Network is its flexibility to respond to the needs of the field. The project is set to work in any priority area specified by the funding agency. Although the project is currently working with transition and supported employment programs, this emphasis could be expanded in future years. However, the project will continue to validate programs in all previously identified priority areas.

Program in Social and Independent Living Skills

Robert Paul Liberman, M.D.; Gayla Blackwell, R.N., M.S.W.; Charles J. Wallace, Ph.D.; Thad Eckman, Ph.D.
Rehabilitation Medicine Service, Brentwood Division, West Los Angeles Veterans Administration Medical Center, Los Angeles, CA 90073

Sponsor: *National Institutes of Health*

Purpose—The objectives of this program are to develop, evaluate, field test, and disseminate a comprehensive set of "modules" for use by mental health and rehabilitation practitioners in teaching

social and independent living skills to severely and chronically ill mental patients. The skill-building techniques are designed to remediate the deficits that prevent patients from attaining successful community adjustment and improved quality of life.

The training technology is organized and designed to maximize its exportability and utilization by service providers in a variety of clinical and applied settings—hospitals, day treatment centers, mental health clinics, residential care facilities, and family homes. The training methods are packaged with highly specific instructional materials in a "module" that consists of a trainer's manual, a patient's workbook, and a demonstration video. The video provides models to highlight the skills to be learned and helps to overcome the cognitive deficits and learning disabilities that are so frequently found with major mental disorders.

Progress—Modules have been developed in several skill areas including "Medication Management," "Recreation for Leisure," "Grooming and Self-Care," "Social Problem Solving," and "Symptom Self-Management." The modules are designed to have patients and staff engaged in an educational process that promotes: 1) practicing the skills that constitute the module in the treatment setting and in the community; and, 2) learning how to solve problems that patients are likely to encounter when using the skills in real-life situations.

The skills are taught using a combination of videotaped demonstration, motivational interactions to ensure active participation by patients, question/answer exercises, roleplays, *in vivo* exercises, and homework assignments. The trainer or therapist takes an active role in prompting and coaching patients to make successive approximations to improved competencies. Each module takes approximately 30-40 hours to complete, depending upon the patient's level of functioning and educational readiness. To contribute to improved clinical outcomes, the modules must be imbedded in a comprehensive treatment program including case management, crisis intervention, pharmacotherapy, liaison with psychiatrists, and other rehabilitation services.

During the past year, the "Medication Management" module was field-tested extensively in over 35 representative clinical facilities throughout the USA. It was found that the module could be readily utilized by diverse staff, with reasonable fidelity in delivering its components, without more training than a brief workshop and follow-up telephone consultation. Patients were able to learn the knowledge and skills involved in self-management of their medication and compliance to medication regimens improved.

Future Plans—Future research efforts will be directed toward evaluating, field-testing, and disseminating the modules that have been developed. Each module will be evaluated with respect to: 1) *skill attainment,* the degree to which patients are able to successfully demonstrate that they have acquired the requisite skills of the module; and 2) *treatment outcome,* the extent to which the requisite skills are maintained by the patient and generalized to the natural environment.

Several of the modules are being evaluated in the context of a 5-year research grant, funded by the National Institute of Mental Health, to determine whether skills training yields improved outcomes (e.g., less relapse, better psychosocial functioning, higher quality of life, lower maintenance neuroleptic medication requirements) in conjunction with a low dose maintenance antipsychotic drug regime. During the next year new modules for training "Conversation Skills" and "Money Management" will be designed.

Advances in Psychosocial Rehabilitation

The Rehabilitation Research and Training Center
Department of Psychiatry and Behavioral Sciences, George Washington University Medical Center, 613 Ross Hall, 2300 Eye Street, N.W., Washington, DC 20037

Sponsor: *National Institute on Disability and Rehabilitation Research*

Background—For several decades researchers and practitioners, and particularly the clients themselves, have recognized that psychological and social factors play a central role in the successful rehabilitation of physical disabilities. During the past two decades there have been promising starts in conceptualizing psychological and social processes common to such disabilities as paraplegia, deafness, blindness, cancer, coronary artery disease, etc. However, it has been difficult to mobilize sustained, programmatic research and training in this area of rehabilitation. Recognizing this lack, the National Institute on Disability and Rehabilitation Research has funded a new center to develop specific research programs and training efforts that will enrich and further define the field of psychosocial rehabilitation. The Rehabilitation Research and Training Center at George Washington University was chosen for this task. The series of five manuals summarized below provide a report on this work, which advances considerably the field of psychosocial rehabilitation.

Developing a Clear Image of the Family: The Card Sort Procedure as an Easy and Precise Method for Measuring Family Process in the Rehabilitation Setting

David Reiss, M.D., and Mary Ellen Oliveri, Ph.D.

Purpose—Family images and rehabilitation. This manual describes in detail a relatively new process for precisely measuring family interaction process. What is the relevance of such a procedure for ordinary rehabilitation practice? There are three fundamental reasons why we present this procedure to the rehabilitation community at this time: i) The family plays a major role in rehabilitation outcome for children and adults; ii) The family is often difficult to assess: it remains important but "invisible"; iii) The procedure for "imaging" the family described in this manual has now been tested with hundreds of families in many settings here and abroad and is clearly ready for more widescale use.

Progress—Family researchers have developed methods of directly observing families in action under standardized conditions and are using precise methods for quantitative measurement. This type of assessment has two forms. The first encourages family members to talk among themselves, either in their home setting or in a research setting. Their interaction may be audio- or video-recorded and then coded with standardized, reliable, and valid codes. However, procedures of this kind are useful only for research. They are not only time-consuming but very expensive. Ten minutes of interaction often takes an hour or more to code by a highly trained coder. Thus, a second form of assessment has been developed. This approach stimulates families to interact in situations in which their behavior is simplified and in which the behavior itself is automatically recorded. Usually family members respond to some sort of puzzle or challenge and must work dials, buttons, cards, switches, or PC paddles to interact with each other and the puzzle materials.

Preliminary Results—This important methodological shortcut has been shown to yield vivid images of family interaction that are both reliable and valid. The Card Sort Procedure (CSP) for families, is the principal example of this form of procedure. This unique procedure is now fully developed and ready for any rehabilitation center or program that is concerned about more careful assessment and support for the families of its clients. After installation,

its costs are very low, and it yields results almost instantaneously. As the manual describes, CSP permits the clinician to determine rapidly the basic problem-solving style of any family with three or more members. This problem-solving style of the family group is not related to intelligence, social class, educational level, culture, or race. Rather, it reflects the family's basic and enduring sense of its relationship to its social world.

These data about families are of critical importance to the rehabilitation practitioner for four reasons: i) The data provide the practitioner with an immediate and firm grasp of the quality of life in the family; its level of optimism, its sense of connectedness or fragmentation, and its rigidity or flexibility. ii) The data provide important clues about how to engage the family in a rehabilitation program, distinguishing those families who typically feel overwhelmed by, and retreat from, any novel social situation from those who readily engage in such situations. iii) As research results emerge, CSP will help identify major risk factors in families. It probably will predict those families who will passively drop out of a rehabilitation program or those who will actively interfere with its success (the status of the "risk" research is summarized in the manual). iv) Finally, the problem-solving task itself is a useful way of engaging families in a rehabilitation program; the professional can provide feedback results to family members almost instantly and can help them recognize patterns of their own interaction behavior that otherwise they might not. A computerized method has been developed by which the entire CSP can be programmed for automatic data acquisition and scoring. This method offers the advantage of speed, ease of data recording, reduction and storage: high test-retest reliability and reduced staff time. In sum, CSP reflects major advances in the field of family assessment. For a modest, nonrecurring cost, a fully computerized version can be located almost anywhere. Little or no training is necessary to administer the procedure.

How Much Self-Sufficiency Does an Adolescent with a Disability Have? A New Approach to Accurate Measurement

Ann Sigafoos, Ph.D.; Carl Feinstein, M.D.; Marietta Damond; David Reiss, M.D.

Purpose—A broad range of severe physical disabilities starts during or before adolescence and continues throughout adult life. These range from cerebral palsy and spina bifida, which are present at birth, to diabetes and crippling arthritis, which often appear in childhood, to epilepsy and blindness, which can occur at any age. Rehabilitation professionals are recognizing that adolescence may be the most critical phase in development for these youngsters with disabilities. In adolescence, they either forge the abilities, drives, and outlook that will propel them toward independent living for the remainder of their years, or they retreat from autonomy and independence to a conception of themselves as relatively helpless and dependent. Recognizing the central importance of this period, contemporary rehabilitation practice has emphasized programs that help the transition of these youngsters from school to work. Given this strong current emphasis on "transitioning," it is remarkable that rehabilitation professionals have virtually nowhere to turn for a systematic, reliable, and valid assessment of autonomous functioning in adolescence. When the professional asks about any given adolescent client, "How much initiative, independence, and autonomy does this youngster show?", he or she must fall back on crude impressions, second-hand accounts, and unreliable guesswork. Given the increasing recognition of the importance of adolescence in the rehabilitation effort, it has become imperative to develop an inexpensive, rapid, comprehensive, reliable, and valid tool for precisely assessing the level of initiative, independence, and autonomy in any teenager.

Progress—The first edition of this manual describes the Autonomous Functioning Checklist (AFC) developed in our Rehabilitation Research and Training Center. It provides the conceptual background of the AFC, compares it to other procedures, and describes how norms were established from a sample of almost 400 adolescents. In addition, it describes the reliability and validity of this instrument. Because the focus of the AFC is on the adolescent's psychosocial adjustment, and because successful

adult adjustment requires that the individual meet, at a minimum, certain critical demands of the environment, the AFC measures independent living behaviors at the level of the central requirements of adult life as indications of psychosocial adjustment to the physical and social surround. At this level, the critical requirements for living are relatively uniform. The ways in which individuals may choose to meet these requirements may not be uniform, and this individual variation in meeting environmental requirements is what the AFC is designed to assess. The AFC's measurement of autonomy as functional autonomy in relation to the requirements of the environment makes the instrument meaningfully applicable to almost any adolescent, regardless of physical, emotional, or cognitive level of functioning.

The AFC contains only information about what the adolescent actually does in daily life. This information can, in turn, be used to assess the effects of relative levels of actual (rather than estimated) competence on other adolescent characteristics, such as psychological functioning or personality. In addition, the method reflects our view that capability is necessary for performance but that autonomous functioning capability is developed and defined by repeated practice of the relevant behaviors. The AFC measures an adolescent's psychosocial adjustment independent of chronological considerations. There is no assumed relation between age group and development of initiative or display of autonomous behaviors. Therefore, the AFC measures both the diversity of the types of the adolescent's experience as well as the accumulation or extent of the adolescent's practice with independent living. Further, the AFC is designed to be uniformly applicable to all adolescents, regardless of the type, degree, or even presence or absence of disability. For this reason, results obtained from the AFC are readily comparable across disability types and between disabled and non-disabled adolescents. The AFC is a 78-item parent-completed behavioral checklist for adolescents between the ages of 12 and 18. It is divided into four conceptually distinct subscales: self and family care, management, recreation, and social and vocational activity. Complete written instructions to the parent are given on the first page of the AFC; therefore, in most cases the parent or caretaker should be able to complete the AFC without assistance.

Preliminary Results—The results of its first administration to a group of adolescents indicate that its subscale scores show definite changes with age and that it has acceptable levels of validity and reliability. The AFC focuses on the behaviors that are, or are becoming, a part of the adolescent's actual behavior pattern. Thus results from diverse groups of adolescents are readily comparable. They provide a critical measure of the extent to which the adolescent is meeting daily demands of the environment in a way that is expectable for adolescents of his or her own age. They are also a measure of the extent to which the adolescent is becoming adequately prepared to function independently in adulthood.

Family-Centered Interventions for People with Chronic Physical Disabilities: The Eight-Session Multiple Family Discussion Group Program

Sandra Gonzalez; Peter Steinglass, M.D.; David Reiss, M.D.

Purpose—Through improved diagnostic and treatment technologies, medical science has increased the survival and upgraded the medical competence of many persons with severe chronic illnesses and disabilities. An obvious concern for rehabilitation specialists is the quality of the extended lifespan of those who must live with these chronic, and often severe, medical conditions. Recently, there has been a growing recognition of the critical role played by the client's family in successful rehabilitation. Even in settings where family involvement is sought and supported by medical treatment and rehabilitation care providers, there has been a persistent, if somewhat variable, difficulty in engaging families in family-focused rehabilitation interventions. Of particular difficulty has been the establishment and maintenance of family meetings or discussion groups that deal with illness-related family dynamics and concerns.

Progress—The Multiple Family Discussion Group (MFDG) program presented in this manual is a short-term (eight weekly sessions) psychoeducationally-oriented, family-focused intervention. The groups bring together four to six entire families, including the index patient, to discuss illness-related family problems in a structured discussion format. The MFDG program offers several advantages over traditional client-focused approaches to long-term psychosocial rehabilitation. First, it addresses the needs and concerns of the group that assumes primary responsibility for day-to-day chronic illness management—the family. Second, by its very composition, it provides a forum for mutual support and sharing of coping strategies for both patients and families. Finally, it is a short-term, cost-effective intervention by which several families are treated simultaneously. The engagement of families in the MFDG program will not be a simple matter. Some of the most important patterns of family response associated with chronic illness are as follows: 1) Families are reluctant to change their ways of handling the illness; 2) Family members are often well aware of feelings of disappointment, anger, guilt, resentment, and helplessness regarding the illness, and they often experience these feelings as unacceptable in light of the patient's medical condition; 3) Family members do not, generally, talk about the illness among themselves; 4) Most families with a chronically ill member report having negative experiences with at least one part of the medical care delivery system; 5) Families coping with a chronic medical condition often feel criticized by the offer of help, particularly if the help is of a psychological nature; 6) Families coping with a chronic medical condition are often unable to find time for another illness-related activity.

There are a number of factors to consider in selecting families for participation in the MFDG program; such as patient participation, households, age, terminal illness, individuals and family psychopathy and group composition. Because of its unique structure—the conjoint meeting of four to six families, including the index patients—the MFDG operates on two distinct levels: an intrafamily level and an interfamily level. On the intrafamily level, the MFDG works like a single-family intervention. On the interfamily level, the MFDG permits family members to more easily observe and understand their own attitudes and behaviors by comparing themselves with other families. The eight sessions are divided into three components, each with distinct goals, as follows: 1. The Educational Component: The first three groups of the MFDG program are focused on "educating" the families about the various ways in which family life is affected by a chronic medical condition. 2. The Individual Family Issues Component: There are two purposes of this component of the MFDG program. The first is to provide each family with the opportunity to focus on a specific family issue or problem and to receive feedback from other families and from the group leaders. Second, the work begun in the educational component is further developed. 3. The Affective Component: The final two sessions of the MFDG program are focused on the family's emotional or affective life as it influences and is influenced by the chronic stress of a serious medical condition.

Preliminary Results—It is hoped that this manual will convey an attitude at the heart of the MFDG program. This attitude, simply stated, is that it is the families themselves who are the ones best able to teach us and each other about the impact of chronic medical conditions on family life and about those attitudes and behaviors that are most helpful in coping successfully with such conditions. The most profound impact of the MFDG intervention may result simply from chronic-illness families meeting together, listening to each other, and sharing their illness-related experiences and concerns.

The Acceptance of Disability Scale

Donald C. Linkowski, Ph.D.

Purpose—Casual and clinical observers have long noted that persons with disabilities demonstrate a wide range of responses to their disabilities. Individuals who have the same or similar disabilities may say very different things about how they feel about themselves as disabled. Some say that they

hate it and that they are worthless: others may acknowledge the inconvenience but recognize that they have many more important characteristics that give them meaning and a purpose in life. The term used to describe this characteristic is "acceptance of disability." Acceptance can be low, as when the person has strong negative feelings usually accompanied by anger, denial, or depression. Acceptance is high when the person feels that the disability is only one characteristic in context with many other abilities and personal assets, and he or she exhibits pride, contentment, or happiness.

Progress—Consistent with other concepts of acceptance is the emphasis that their theory places on the subjective meaning of the disability to the impaired individual and the associated emotions and values. Wright (1960) summarizes the process of acceptance of loss as a series of value changes. The nature of these value shifts characteristic of individuals with physical disabilities who have come to accept their loss are as follows (Linkowski, 1971). 1) Enlargement of scope of values. The extent to which a person is able to see values other than those that are in direct conflict with the disability. 2) Subordination of physique. The extent to which a person is able to deemphasize aspects of physical ability and appearance that contradict his or her disabled condition. 3) Containment of disability effects. The extent to which a person is able to restrict his or her handicap to the actual physical impairment, rather than spreading it to other aspects of the functioning self. 4) Transformation from comparative to asset values. The extent to which a person does not compare himself or herself to others in terms of the areas of limitations and liabilities, but rather emphasizes his or her own assets and abilities. The Acceptance of Disability (AD) scale was developed to understand the wide variation in behavior of persons with disabilities. Specifically, the intent is to test for relations with personal adjustment and rehabilitation outcome variables. Acceptance of disability is assumed to be an important "mediating" variable. It can assist researchers and practitioners in understanding the connection between the person's disability and self-perception and, further, in predicting independent living, educational, and vocational rehabilitation program-related outcomes.

Preliminary Results—The AD scale contains 50 items consisting of statements derived from the four aspects of the theory of acceptance of loss described above. The items in this self-report inventory were developed by the author and independently evaluated for clarity of statement and assessment of the value areas of two experts in rehabilitation counseling. Items that were judged as unclear or not central to the theory were either revised or discarded in the development of the scale. The content validity of the items was also ascertained by means of expert opinion. The AD scale was constructed to be administered directly to disabled subjects. It is an important tool for understanding and predicting the behavior of persons with disabilities, regardless of their race, sex, age, or diagnosis. The demonstrated reliability and validity of the AD scale also indicates that the measure can be adopted for clinical use in counseling and for other therapeutic purposes in rehabilitation. The manual was prepared as a preprint to provide information about this instrument as rapidly as possible and the complete instrument and instructions for administration and scoring are included in it. The AD Scale has been copyrighted by its author, Dr. Donald Linkowski.

The Issues in Disability Scale: A New Cognitive and Affective Measure of Attitudes Toward People with Physical Disabilities

E. Makas; P. Finnerty-Fried; Ann Sigafoos, Ph.D.; David Reiss, M.D.

Purpose—Recent legislation leading to the mainstreaming of disabled individuals into all sectors of society has generated considerable interest in the measurement of attitudes of nondisabled people toward people with disabilities. This interest has resulted in the development of a wide array of instruments to measure these attitudes. The aim of our research was to develop a measure that pre-

serves the valuable information gained through previous research while taking into consideration the criticisms of previous attitudinal measures.

Progress—The Issues in Disability Scale (IDS) was developed in response to this need for a new instrument to measure attitudes toward persons with disabilities. The 55-item IDS is a Likert-type scale that is based, in part, on existing measures and has been designed specifically to take into consideration criticisms of existing instrumentation. Existing instruments were examined to produce concepts to be included in the IDS item pool. Attempts were made in the selection of concepts and in the wording of items for the initial item pool, however, both to represent the multidimensionality of attitudes and to reduce the demands of social desirability. In addition, the final selection of items was based on strict reliability criteria. We also determined that initial validation of the scale would be based on behavioral as well as nonbehavioral assessment. An initial pool of 143 items was developed for possible inclusion in the IDS. These items were drawn from three main sources: i) existing attitudinal measures; ii) analysis of responses to a semantic differential pretest; and iii) consultation with disabled individuals. Approximately 75 percent of the items in the initial pool were adapted from, or suggested by, existing scales.

After the development of the initial item pool, the items were submitted to a panel of 13 individuals having expertise in one or more of the following areas: attitudes toward disabled people, attitudes toward other minority groups, and attitudinal assessment. In all, 43 items were removed from the scale, resulting in an initial IDS instrument composed of 100 items. The 100 items remaining in the item pool were arranged somewhat randomly, although consideration was given to separating items that were similar in content (e.g., setting or social distance) or target (disabled people in general or people with named disabilities). Items were placed in a seven-point Likert-type format, ranging from "strongly agree" to "strongly disagree," with a midpoint labeled "don't know/no opinion." The items were checked to ensure that they reflected an approximately equal split between positively-worded and negatively-worded statements. The 100 items were administered to two samples: i) a student sample; and ii) a "good attitudes" sample.

Preliminary Results—Analyses suggested the placement of items into six subscales on the basis of social setting. These six subscales are: i) Education: items dealing with the abilities of children and adolescents with disabilities to function in mainstreamed classroom settings (e.g. "The majority of physically disabled adolescents should attend special schools which are specifically designed to meet their needs."); ii) Legal: items dealing with legislation applicable to disabled persons (e.g., "It is illegal in most states for people who have hereditary disabilities to be sterilized without their permission."); iii) Intimate Social: Items dealing with close interpersonal interaction between disabled and nondisabled persons (e.g., "Most married couples do not get divorced when one of them becomes disabled."); iv) Non-Intimate Social: items dealing with casual interpersonal contact (e.g., "One should avoid asking disabled people questions about their disabilities."); v) Physiological Abilities: items dealing with a disabled person's actual physical abilities (e.g., "Most blind people are self-sufficient and do not need assistance in their daily activities."); and vi) Psychological Characteristics: items dealing with a disabled person's emotional and psychological characteristics (e.g., "Disabled people are generally no more anxious or tense than nondisabled people."). Theoretical analyses of the relatively high intercorrelations among some of the subscales support, rather than discredit, the multidimensionality of attitudes toward disabled people as assessed by the IDS.

Future Plans/Implications—Analyses are now underway to assess the IDS's susceptibility to social desirability demands and its fakeability relative to the ATDP scale. Further research with the IDS is necessary, however, to determine the scale's construct validity on the basis of other demographic variables (e.g., professional specialization, education); its concurrent validity with other attitudinal measures; and its behavioral validity in a wide array of interactions between disabled and nondisabled persons.